

Concrete Mix Design

* ورد بالقرعة أن مواصفات الزئونة تكون
التركيب أو الاختيارية أو اللطائف أو الواسعة

* تم وضع المواصفات Technical Specifications في المواصفات كآ
التركيب

* تم وضع "Memorandum of Understanding" MOU
أما مواصفات الزئونة فتكون التركيب أو اللطائف

* مع المبدأ هو أن يتم وضع المواصفات في المواصفات كآ
أو التركيب أو اللطائف أو الواسعة أو اللطائف أو الواسعة

طبقاً لما جاء في MOU في "Din 1045/1988"
المرجع: ٢ / ٤ / ٤

المرجع: ٢ / ٤ / ٤ - Fly Ash - التركيب أو اللطائف أو الواسعة
المرجع: ٢ / ٤ / ٤ - التركيب أو اللطائف أو الواسعة

Introduction

This documents covers the requirements for the R.C and plain concrete as described in Volume 3 P.T.S. Section 5 Concrete.

This specification is based on the Din 1045 1988 and the related standards, Specification and recommendations.

For the selection of specification with acceptance Criteria and test methods the following documents are used:

- Main Contract Volume 3 P.T.S.
- Din standards and related Documents
- ASTM and ACI Standards التركيب
- NFP Standard الواسعة
- other standard

Cement

- The Cement is produced and supply from "Egyptian Cement Company" ECC in Suez area
- The plant has sufficient capacity for the Cement Supply of Naga Hammadi Barrage.
- The Cement is delivered as bulk material by special weather-tight silo trucks.
- The following types of O.P.C. are intended to use:
 - ~~CEM~~ CEM I 42.5 low alkali (LA)
 - CEM I 42.5 low alkali, low heat of hydration (LA, LH)
- The CEM I 42.5 low alkali, low heat of hydration will be used ~~as one~~ for the mass concrete.
- The CEM I 42.5 low alkali will be used for structural concrete not described as mass concrete.
- For every delivery of Cement a test Certificate has to be submitted to the site, cover the chemical and physical properties.

Fly ash

- The Fly ash which will be used imported from India
- The Fly ash is shipped in big bags to an Egyptian harbour and delivered to site by trucks
- Fly ash will be used for ~~the~~ mass concrete structure for the structural concrete not described as a mass concrete may also be ~~applied~~ employed in case required.
- For every delivery of Fly ash a test Certificate has to be submitted to the site, cover the chemical and physical properties.

Cementitious Blend

To control the heat of Hydration cause by the total amount of portland Cement in the concrete Mix or Cementitious blend will be used, this blend will be applied for all structures, which are classified as Mass concrete. to obtain the Max Core Temp. 53°C

Sand & Aggregates

- Sand & Aggregates shall comply with the Din 4225/1983 and the properties as specified in PTS Section 5
- In general the limits of the PTS will be applied if they are not in Contradiction with Din 4225
- For material properties required by ^{the} PTS, which are not covered by the Din 4225/1983 test methods, Din EN or ASTM Test method will be apply.

Definitions

- Natural sand and aggregates = Uncrushed and crushed dense material.
- Artificial sand and aggregates = Artificially produced crushed and uncrushed materials air-cooled blast furnace slag^{or cinders}
- Crushed stones: The product resulting from the artificial crushing of rocks, boulders or ~~large~~ large Cobblestone, substantially ~~at~~ all faces resulting from crushing operation
- Gravel = Coarse aggregates resulting from natural disintegration and abrasion of rocks or ~~prosse~~ processing of weakly bound conglomerate.

Alkali Silica Reactivity

- The NF-P البيكيت will be applied for an assessment on alkali reactivity for classification of sources.
- The required classification of are
 - not reactive NR
 - potential reactive with pessimum "PRP"
- potential reactive aggregates may be used as well if a study of concrete formulation is carried out on an experimental basis.

Sand:

- The sand consists of processed nature material, which is well graded and washed if necessary.
- Naga Mazen Iabeb Sand Quarry is the present source
- The Max Sulfat and chloride contents are according to the Din 4226 1983 limits.

Aggregates

The available sources now are containing sufficient quantity of aggregate, In Bala Bish Bahari area and these quantities contains 8 potential reactive Alkali.

The performance of the processing equipment shall be designed to meet the required amounts for concrete production.

- 2 size of aggregate will be used
4 - 16 mm 7 - 16 - 32 mm

- All coarse aggregate fraction will be washed on site if necessary.

Mixing water

The mixing water shall comply with:

- The German Concrete and Construction Association
- Code of practice for Mixing water for Concrete
- Additional properties of P.T.S. Sec. 5

* The intention of this code of practice to determine the usability of natural water sources for concrete production and the routine testing during production

* No regular testing of Mixing water are required after the Sources are established, unless required by the Employer or when the water is contaminated during works.

Admixtures

* Admixture comply with ASTM C 494 are produced and supplied by MBT

* The chemical and physical properties of the Admixture proposed for production will be confirmed by testing in an independent laboratories prior to use.

* Every delivery will comply by a technical data sheet or test report to verify that the admixture comply with the ASTM C 494

Concrete

General

* For each trial Mix a detailed concrete mix design will be performed. The Mix design will include the following details:

- Concrete Mix identification number
- Specification of the Concrete Mix (i.e. type of concrete, strength, aggregate size consistency class)

- Content of cement, fly ash, mixing water, chemical adm., entrapped air, sand and each size of aggregate.
- W/C ratio
- Fresh concrete density, fines content (0.15, 0.25 m_m) mortar content (2 and 4 m_m)
- Total content of chloride, sulfate and Na_2O
- plot of the combined grading chart according to Din 1045 Charts.

* The General limits for the concrete composition in this part are based ~~the~~ on the requirement of Din 1045/1988

~~ATTN~~ All types of concrete of table 5.2 of the P.T.S are defined as water resistant (water tight concrete)

Consistency

The acceptance criteria for the ~~slump~~ slump will be in a range of $\pm 1 - 2.5$ cm of the designed slump for the flow method the slump will be in the range of $\pm 1 - 3$ cm of the designed value

Strength

Temperature Control

The heat of Hydration ~~test~~ development for the mass concrete during initial testing will be determine by a large-scale trial ~~test~~ using $3m \times 3m \times 3m$ concrete block.

الوقت ٢٠١٤/٢/٦

مخارج حماية البر الايسر للنيل

* طرق د. حصة
د. كريمة

تم عقد جولة النيل ورأس ن. حترال في حماية البر الغربي
للنيل بمساحة ١٠٠٠٠ م² ليعمل Closure Dike وحماية في المساحة
المختلطة والتي تقل عن ١٠٠٠ م² (١٠٠٠ م²)
حيث أنه من سوء الفهم أن القنطرة بعد الانتهاء من العمل
تقل إلى (٩٠,٩)

ورأس ليعمل من خارج ليعمل في مساحة ١٠٠٠٠ م² المساحة الخارجة
والا مساحة أيضا بخط التوزيع على رأس ٦٥٠ م²
مكتوبة اليوم - حيث أنه خط التوزيع الطولي ١٠٠٠ م² يكون
٢٥٠ م² يكون مكتوب في اليوم

* Construction pit

بدراسة الفخا

الوقت ٢٠١٤/٢/٧

د. أبو الفيد

- انقل د. حصة من طريق البساتين إلى طريق
الاستقرار في التقرر الخاص بأبواب الاستقرار في

مساحة العمل

١- خريطة A3 على Coordinates للامانة الاستقرار في
٢- A3 على Coordinates للامانة Partial

Data Base of the project

- انقل د. حصة من الجامعة القومية طابقت على قاعدة بيانات - ليعمل

Concrete Mix Design

* رابع طلاء الطابقي 1040 في 10/11/2004 تم الرد به جابجا
المرجع بكتاب رقم 697 في 10/11/2004 به الليرة
في اللوحات التي هي في قوتها في الجدران عند اعتبارها شاري
رودة في الجدران وعند تصميم الخلطة المرشحة.

في انظار داتة تصميم الخلطة المرشحة مع د. سميت من ليرطير
وضع ان هناك - كم - كمية كلغة في الزعفران و"Alkali Reactivity"
وهو قاتل الرطام للتفاعل
وقد وضع ان انواع الرطام الموجودة في المنطقة قابلة جزيا للتفاعل
PRP 'potential reactive with prissimum'
وهو قد تم انظار 'approved' في الخلطة المرشحة N كما في امانة
داتة انظر هذا الفصل في الاعلى
في هذا فقد تم احيال الخلطة المرشحة الى المختبر في ليرطير

letter N° 1187 Dated 7/13/2004

From Consultant → Contractor.

subject: Cut-off wall under permanent structures
plastic concrete, AL Kali Reactivity test

stated:

~~that~~ we refer to the letter N° 755 dated 6/19/2003 in
which plastic concrete Mix M₁ was considered suitable
for the "Permanent Cut-off wall". In meantime some
strong concerns about the AL Kali Reactivity for the
the aggregates available near to the site.

In view for this situation, we consider that the
plastic concrete Mix M₁ should included in the test
series to investigate this problem in the French laboratory.

اختراع د. سمیت - اوسترہاس اے م / اے کرات اے م / صبر
دعا ملانے نام ملل پاری د. سمیت
راضیہ الملقات اسم - Alkali Reactivity وقد انشیا الی
الوصیات الی -

- ١- فتح القام بتدول كل الجود المحلة بمادة الحكي عن مفاير لطيفه جواهر
٢- ~~فتح القام~~ المطارل ارسال عيات من الحماير الوصل عيل الى
المال القرن لعل الاضيا رات الذرية.

وقد أتممت النقاط الواردة مع درسيته خلال هذا الأسبوع
مع النقاط الإيجابية التالية :-
- العودة الى حجم الرقم ٥٠ ص بعد ان كان الـ ١٠٠ ص في المجلد
المرحلات مع هذا ٢٢ ص

الدقة ٨ / ٤ / ٢٠٠٤ ٣ / ٢ / ٢٠٠٤

$$\begin{array}{r} \text{حاصل} \quad 21,7.9 \\ \text{موجود} \quad 14,- \\ \hline 8,7.9 \end{array}$$

23/11/23

سورة حلوان

الف $8, 7, 9 + 1, 5, 7, 8$ أقل من صفح 2 الف $7, 8, 11, 27$

المرد = 72,7%

9, 11, 7 5, 10, 6

اجراءات القصد
+ 100 -

1.127 المعاني

الفصل الثامن عشر في الصلاة

$$15, 1A1 = 1 - 1 \times 15, 4 \mu V$$
$$0.475 = \frac{1}{1 + 1.5 \times 10^{-5}}$$

14,050 305

$\sum_{i=1}^n C_i = 14,080 + 1,147 + 97,77 = 112,997$ = المبلغ الإجمالي

10.7.01 22.11

Concrete Mix Design

دائرة الحاد درجہ صفر ALKali Aggregate Reactivity

هو ما يسمى المقام القلبي للعلم

هذا - مع العلمات أو الصلوات - هذا الموضوع.

ح إذا استعملت حرام فقابل للاتصال مع استناب به ليخاف عالياً من العكليات
فثبتت اتصال بين هذا الرام والعكليات فينتج عنه زيادة في الحجم في
أحياناً بعد استناب أو أكثر من صلب الإنسان وينتج عنه هذه الزيادة
تكون رافقت الإنسانية .

[illegible]

- لعل هذه الشاكلة يراد بها التأكد من عدم قابلية الركام ~~للزحف~~ للقفل
وكنهه كثير من الصلوات المستحقة بما لا يتصوره ولا يدركه
الاستحياء

- * Some of the aggregates contain reactive silica, which reacts with alkalis present in cement i.e. Sodium oxide and potassium oxide.

x AS a result of reactions, the Alkali silicates gels of un limited swelling type are formed causing disruption of concrete

كما أنه وجد في العرض المقدم من المقاول "offer" أنه يتخير المالك
 للمورد في ملء "البوصلة" مع له حسم .
 وتم إرسال كتاب في المصنفات إلى المصنفات

Letter No 768 Dated 9/3/2004
 From Employer → Consultant

المرسلات ١٥ / ٣ / ٢٠٠٤

المصنفات

اقبل مع "عمل وورد" ولان المصنفات متصلا في مكان اعادة
 دفع عليه ٤٩. المصنفات المصنفات ووقفت عليه

التمتع الموقت الثاني

فهم العرض كله التمتع الموقت الثاني الذي الذي يخصه عدم قابلية التمتع
 الموقت الثاني إلى أنه المصنفات مع موانع المصنفات المصنفات
 يتم التأكيد عدم عدم قابلية التمتع الثاني أي من المصنفات ويطاط المصنفات
 ليس ... ويتم العرض متصلا على مصنفات ويطاط المصنفات

وهذه الأسباب جارية حاليا التأكيد في المصنفات المختلفة وهي :-

١- تم دمج داعم لخدمة المصنفات بدلا من التمتع الموقت
 وهو ما يجعل كثيرا والمصنفات على مطلوبة في الانتظار المصنفات
 في المصنفات ... فقد عملنا المصنفات المصنفات
 ... هناك المصنفات المصنفات المصنفات المصنفات المصنفات
 ونقل إلى المصنفات المصنفات المصنفات المصنفات المصنفات
 قطع المصنفات المصنفات المصنفات المصنفات المصنفات
 اصحاب

وبناء على ما سبق ذكره المصنفات المصنفات المصنفات المصنفات

١	٧٧,٥	مضان	مضان	مضان	مضان
٢	٤٤	مضان	مضان	مضان	مضان
٣	١٥,٥	مضان	مضان	مضان	مضان
٤	١٦,٤	مضان	مضان	مضان	مضان
٥	١١	مضان	مضان	مضان	مضان

الحمد لله رب العالمين ٢٠٢٢/١١/٢٠

مادة كيمياء البناء - ٢٠٢٢ - ٢٠٢٣

Alkali Reaction aggregates

High Alkali content in Cement

The Alkali Content to less than 0.6% is considered Low alkali Cement,

Field Experience has never detected serious deterioration of concrete through the process of Alkali aggregate reaction when Cement contained alkali less than 0.6%.

The presence of water is very important to increase the availability of alkali aggregate reaction in concrete.

It has been seen in the field and laboratory that lack of water greatly reduce this kind of deterioration due to alkali aggregate will not ~~occur~~ occur in the interior of mass concrete.

The deterioration will be more in the Surface.

The Ideal temperature for the promotion of alkali aggregate reaction is in the range of $10 - 38^{\circ}\text{C}$. If the temperature condition is more or less than the above, it may not provide an ideal situation for alkali aggregate reaction.

Mechanism of Deterioration of concrete through the alkali aggregate Reaction

~~The Mechanism~~ The Mechanism of alkali aggregate reaction has not been perfectly understood. However from the known information the mechanism of deterioration is explained as follows:-

- The mixing water turns to be a strongly caustic solution due to solubility of alkalis from the cement.

- This caustic liquid attacks reactive silica to form alkali silica gel of unlimited swelling type.

- This silica gels grows in size, the continuous grows in silica gels causing osmotic pressure.

The letter self explanatory.

- The second to send the letters to the Contractor directly from our side and copy for the Consultant.

At the end of the discussion we agreed that:

1. Send the letter to the Consultant as usual, and the Consultant from his side sends the letters with "Statement self explanatory to the Contractor, in the case the normal letter.
2. If the letter Consultant don't agree of the letters contains he it will discuss the matter with us to reach a correct way according the Contract.

Meeting on the Site @ 2.00 P.M

Att. Mr. Rolain Dr. Kholi

M. Fyaler

* M. Herr

✓ Concrete Mix Design

- The ~~the~~ Lab. C.B.T.P. is ^{not.} Independent
- The Contractor make test about the stability of slope of Dr. Canal
- ~~The~~ Many V.O not yet Issued. tell now about 8 V.O
- The problem of upleft have been checked by the Consultant, and the Design is O.K.
- The Contractor & the Consultant mutually the Calculations
- The Insurance pt problem with Mier Insurance.

وقد خادع في "جبل بوردون" مع الاضيق الى ايمان بان سبي
الجوالموتر مع متر "صايد" هو محاولة الحل الودي بين المصالح والمصالح
لهم، صار الاضيق في هذا الاتجاه.

وقد طلبت من الاضيق "جبل بوردون" الاضيق من صياح باركر مثل
الاضيق الودي الودي Contractual Meeting. صياح باركر محاولة
في الجوالموتر.

Concrete Mix Design

في آخر يوم الاثنين 14/1/2004 المعلن CEBTP فوجنا فوجنا لال الطول. لنا
Letter No 324 Dated 14/1/2004

From Consultant → Employer

subject: Concrete aggregates and CEBTB testing.

Stated that: "E Qualification of CEBTA

The following Comments provided in reply to the Contractor's
letters with regards to the Qualification of external laboratories
CEBTP:

- We do not comment on the qualification of CEBTA, but we herein^{after}
comment on the procedure how this laboratory was selected
and apparently employed to carry out testing related to
the project
- We do not comprehend why it took 16 weeks, from the date
of sampling (for testing at CEBTP) until the receipt of
the application for approval of this laboratory. it considered
as fundamental to involve the Employer/Consultant in such
essential prior to producing facts.
- It is out of question that at JV's Liberty that the
contractor may carry out of any testing ~~they have obtained~~
~~prior the approval of the Employer~~ they considered
necessary to identify suitable material sources.

however, results obtained through testing by any laboratory chosen unilaterally by J.V., without having ~~the~~ obtained prior consent by the Employer, are generally to be considered as for information only.

- Since J.V. have undertaken on their own responsibility to engage CEBTP, without having obtained prior approval by the Employer, it remains then upon the Employer's Consultant's discretion to ~~and~~ consider or not the achieved test result for approval of using the tested material in the works, should there remain any doubts by the Employer or the Consultant, the concerned result will therefore be discarded.

- For this ~~reason~~ reasons, we are not in position to approve the CEBTP, but reserve our right to request additional testing on the Contractor's costs, performed by a laboratory selected by the Employer/Consultant, or to attend on the Contractor's expenses all relevant stages of testing performed at CEBTP.

- Furthermore, from J.V.'s submissions referenced ...
---), it noted that essential parts of Test Report 2 V, are available in French only, Considering the relevance of the concerned test, it is required to timely receive the related documentation in the ~~proj~~ project language (English). It not acceptable, to receive - three months after the receipt of the concerned samples by the laboratories - the report of the petrographic test examination in French only.

Concrete Mix Design

خطا: الى مهندسك، بناءً على استشارة المهندس أحمد فؤاد، من مهندسي
في 10/5/2024، وبناءً على ملاحظات المهندس أحمد فؤاد، في ملاحظات

Letter No 1281 Dated 10/5/2024

From Consultant → Contractor

Sub: Concrete aggregates testing

Stated: The Employer / Consultant's position with respect to
CEBTP lab has not changed, the same applies now to
Helio polis Concrete Center and the Arduman ACE laboratory
Consequently, all information received is considered as
for information only

Sampling for Suitability Testing of sand and aggregates
which is intended to be considered for the approval
of Concrete Mixes, has generally to be witnessed by
Employer / Consultant

The sampling for Naga Mahen / Bulabish borrow areas can only
be considered as a pre-selection of possible borrow areas. due to
the large distances between the sample locations, a systematic
investigation approach has to be the top priority if the Contractor
considers this areas as his preferable areas.

The situation as described above is not in the line of good
technical practice and we expect your detailed programme
of investigation including a new time scheduling, particularly
preferred sources of aggregates, cementitious materials and
mixing recipes shall be decided and advised as shortly as
possible to enable cross-checking in a laboratory of Employer/
Consultant's choice

Effect of Alkali Silika Reactivity for permanent cutoff wall

على أن لا يترك أي أثر، (الزيت و...)
 potential Alkali Reactive
 (Dr. A. le Raux)
 letter No 1458 Dated 7/7/2004

From : Contractor to Consultant
 Subject: permanent cutoff wall- Plastic Concret
 ASR (Alkali Silika Reactivity)

stated : Conclusion

In the present case, due to the use of Potential Reactive aggregate, a chemical attack by alkalis can not be rejected. On another hand, this attack gives a product of reaction like a gel, which will take place in the pores filled with water of the kind of concrete. The plastic character of this type of concrete (low Young Modulus), and its high content of water absorbed at the surface of bentonite thin sheets, inhibits the mechanical effect such as the formation and development of harmful network of cracks.

Consequently, I believe that even if an alkali Silika reaction could occur in this type of concrete, it will not affect the Final properties of the concrete.

والوقت هذا من شأنه أن يقلل من المتانة...
 كما وأن هذا الجبل عند إنتفاضة يقلل من هجم السطح، العجوة الموجودة بالحدود

* المطامير المائية
 1150.

+ 100% أقل من

Effect of Alkali Silica Reactivity

* التأثير الناتج

استمرار التقرير الذي أيجل من قبل اللجنة رتبة الملائمة مع م - مستند طلبنا
منه أنه يقيم به راسخ هذا الموضوع عند أخذ الاستنتاجات من المختبر صم المصنوع
للإدارة برأيه في هذا الموضوع. وقد أضافوا إجراء تجارب تحققه أو تؤكد عدم
تأثير Alkali Silica Reactivity على البناء الناتجة

وقد أيجل التقرير إلى د. - ييجل رد. إلى سبب في ألمانيا ضد
المجلس البلدي محل البناء يقوم بعين تجارب تأكيدية مع صخر مرص
ولكن ردهم أنهم أنفسهم يتفقون مع رأي اللجنة الذي أحضرته اللجنة رأيه
للأمر طالما أنه يتم Alkali لا يتعدى 2 كجم/م³
في أجل المبنى - تجارب حطاط في الماضي وأشار منه أنه يمكن له
الـ Alkali أن 2.7 كجم/م³ كميان أكبر وانه سيهدد هذا التأكيد يعتبر أنه
في الكمية المنتجة سيتم الاستمرار في العمل بعد اعتمادها
في تقرير د. - ييجل 4 الوثيقة إلى سبب

".. we fully agree with Mr. Le Roux. if an aggregate
is only potentially reactive an alkali content of less than
3 kg/m³ would lead to no harmful ASR. Alkali Silica React.
even if there will occur a reaction it could not affect the
properties of the hardened concrete the elastic modulus
because the elastic modulus of this concrete is very low."

Dr. F. Sielke

Eng. F. Elckschien

Letter No 379 Dated 3/8/2004

From Consultant → Employer.

Subject: Permanent cut-off wall
plastic concrete ASR

stated: "Based on the above we have concluded that the
use of the selected plastic concrete M1 is acceptable for
the permanent cut-off wall, providing that the total alkali-
equivalent content does not exceed 2.7 kg/m³.

Thus, the possibility the Alkali Silica Reactivity reactions
could occur in the P.C.W made by using plastic concrete M1a
with an alkali content of less than 2.7 kg/m³ is deemed to be
very low. On the other side of even if an alkali Silica

reaction would take place, then it would ~~be~~ not be deleterious because of the very high w/c ratio of Mix M₁ (w/c = 2.8 resulting from 380 kg/m³ of water in the Mix)

This high w/c ratio lead to a comparatively high porosity. due to large quantity of excess water, consequently there is sufficient pore volume available in the plastic concrete to accommodate the gel-like reaction products of an unlikely alkali silica reaction without causing any cracks, and without also affecting the mechanical properties of the concrete.

In our opinion, there is now no further basis for any doubts regarding the use of plastic concrete Mix M₁ for the permanent cut off wall, subject to regular verification of compliance with the d/m limit for the total alkali equivalent content stipulated above.

We assume that you concur with our opinion, and we will proceed accordingly, unless we hear from your side.

Integrated program

كافة العينات - (1) و (2) لوت
Lot (1) & Lot (2)

أثناء الفترة من ٤ - ٤ / ٨ / ٤

أشهر الإصدار على النتائج كالتالي:-

- الإبقاء على جميع طوبو الفترة وأماكن ومناطق تركيب العينات المبردة لـ Lot 2
بعد ذلك لوت 1 جميع طوبو الفترة المبردة للترقق سوف يتم مع
إصدار طوبو لوت 2 من حينها الطوبو لم يقرر من
وصول 7.6.1 لظروف القوة و 1.1/1 للظروف المبردة
من موقع (6) إلى موقع السر دافتر construction pit من أجل
المدى والسوية وكذلك يتم إقامة مع أماكن تقوية الأساس وجميع
الأساس الزاوية.

- نظرًا لأنه من المستطاع أن تتقدم بإعمال المبردة مع البراج القصبية القارية
فقط لوت I لوت 1. لوت 1 الإجراء المبردة في الأساسات في مواقع غير متبردة

To: Consultant

Ref. No: NH01/T/00697

Att: Mr. B.R.Hein (Chief Resident Engineer)

Date: 05/01/2004

Cc:

No. of Pages: 1

Subject: Concrete Mix Design.

Dear Sir,

Reference to the Contractor's letters NH01/NHBDC/T/1040 dated 04th December 2003 enclosed by the document:-

▪ NH01 P 00 JV SPE 1028 A

**Concrete and Concrete ingredients
Site Specification.**

Kindly be informed that we have the following comments:-

General:

- 1- Any deviation from the PTS or any additional tests suggested by this report will be born by the Contractor.
- 2- There are some missed specifications (see the attachment).
- 3- The acceptance Criteria for all the materials and the Concrete must be noted by the reference Specifications (separate column must be added to all the tables).

The decided comments, we will the same numbering as used by the Contractor on his a.m. letter:

2. Cement

2.1 General

- a) The Contractor should justify why he suggests to use low alkali (LA) cement
- b) It's required to clear that the Cement will be used according to the results of the Chemical analyses, setting time, fineness, and soundness, the Contractor will be responsible for the rest results.

2.2 Cement Specification for mass Concrete- Initial selection. (CEM I 42.5 N)

- a) Item 2.2.3 Sulphate content (SO_3) the correct limit is 3.5 %.
- b) Item 2.2.7 SiO_2 Content the correct limit is 50.0 %.
- c) Item 2.2.20 the maximum limit of the Compressive strength is 62.5 N/mm²
- d) Heat of Hydration test according to NF P 15-436:1988.

2.3 Cement Specification for mass Concrete- Initial selection. (CEM I 42.5 R)

- a) Item 2.3.20 the maximum limit of the Compressive strength is 62.5 N/mm²
- b) Heat of Hydration test according to NF P 15-436:1988.

Rec. Nermen
05-01-04

El. Alwan

2.4 Cement Specification for mass concrete- Routine testing

- a) Chemical properties and heat of Hydration frequency are 5000.0 ton or 3 month.
- b) Heat of Hydration test according to NF P 15-436:1988.
- c) Item 2.4.20 the maximum limit of the Compressive strength is 62.5 N/mm²
- d) Item 2.4.25.storage limitation for the cement in bags 90 days according to PTS item 5.5.1.8.
- e) Item 2.4.26.The cement temperature at entering to the mixture shall not exceed 50⁰C according to PTS item 5.5.1.9.
- f) Note 2 Values of test certificate; further analysis in case of doubt only. Has to be deleted.

2.5 Cement Specification for other structural concrete- Routine testing

- a) Chemical properties and heat of Hydration frequency are 5000.0 ton or 3 months if the quarterly consumption is less than 5000 ton.
- b) Heat of Hydration test according to NF P 15-436:1988.
- c) Item 2.5.19. the maximum limit of the Compressive strength is 62.5 N/mm²
- d) Item 2.5.24.storage limitation for the cement in bags 90 days according to PTS item 5.5.1.8.
- e) Item 2.5.25.The cement temperature at entering to the mixture shall not exceed 50⁰C according to PTS item 5.5.1.9.
- f) Note 2 Values of test certificate; analysis in case of doubt only. Has to be deleted.

3.3 Fly ash specification for concrete- Routine testing

- a) Chemical properties and heat of Hydration frequency are 5000.0 ton or 3 months. if the quarterly consumption is less than 5000 ton.

4. Cementitious Blend

4.1 General

- a) The last paragraph must be deleted and every kind of cementitious materials must be tested separately.

4.2 Cementitious Blend Specification for mass Concrete- Initial selection.

- a) Item 4.2.6 initial setting max. 180 minutes according to PTS 5.21table 5.3.
- b) Item 4.2.11 Potential alkali reactivity must tested at 6 & 12 months according to ASTM C227 .

4.3 Cementitious Blend Specification for mass Concrete- Routine testing.

- a) Item 4.3.6 initial setting max. 180 minutes according to PTS 5.21table 5.3.

- b) Item 4.3.8 heat of hydration for elements must be less than 200J/g and 250J/g for elements contact and not contact with water respectively.

5. Sand and Aggregate

5.1 General.

According to the PTS 5.21 table 5.2 the maximum size of Aggregate is 50 mm for the mass concrete 25/50, while the max. Size in this report is 32mm, is that means this size suggested by the Contractor for the mass concrete?

5.1.1 Alkali Silica Reactivity

What is the meaning of the last paragraph?

5.1.4 Testing

- a) The soundness test will be every 10000 m³ and 2000 m³ of concrete for the gravel and sand respectively.

5.3 Sand and Aggregate Specification for Concrete- Routine testing

- a) Item 5.3.9 Equivalent sand value once 3 tests during day when the concrete plant is operating.
b) Item 5.3.15, see notice above on testing.

5. Mixing Water

The German code for mixing water is required for Compression.

7. Admixtures

7.1 General

The admixtures are produces according to ASTM C494, so the tests also must be according to this specification.

8. Concrete.

8.1 General

- a) The sentence (no limitation of water / cement ratio) must be deleted.

8.1 Strength

- a) According to MOU clause 6.8 the cubes for testing the concrete must be 200x200x200 mm
b) The acceptance criteria of the concrete (compressive strength) according to DIN 1045 are based on 28 days results.
c) The test frequency of routine of the concrete has to be according to PTS item 5.4.2.7.
d) What is the meaning of the last paragraph of this part

8.4 Schmidt hammer testing

- a) This method will be employed at structural in case of deviations of the 7, 28, and 90 days; are there a limit at 7 and 90 days.

8.6 Structural and mass concrete specification- Trial mixes

- a) Item 8.6.18. Water resistance max 30 mm according to DIN 1045/ZTV-W.

8.7 Structural and mass concrete specification- Trial mixes routine testing.

- a) Item 8.7.4 to Item 8.7.6 Calculation must be explained.
b) Item 8.7.12 frequency of the compressive strength must be according to PTS 5.4.2.7

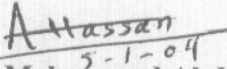
You are kindly requested to check these comments and confirm that they are accurate.

We are forwarding for a meeting with you as soon as possible.

Thank you

Yours Sincerely,

The Project Resident Engineer


(Eng. / Mohammed Abd El Aal)

A. Karret



Encl: one table

Missed Specifications:-

Concrete	
Cement	
DIN EN 196-21:1990	Methods of testing cement -Determination of the chloride, carbon dioxide and alkali content of cement
Fly ash	
DAfStb Code of practice: 1996	Application of fly ash according to DIN EN 450 in concrete construction
Cementitious biend	
Sand and aggregates	
DIN 4226-1:1983	Aggregates for concrete Aggregates of dense structure - Terminology. designation and requirements.
DIN 4226-3:1983	Aggregates for concrete - Testing of heavy and lightweight aggregates
DIN EN 1097-2:1998	Testing for mechanical and physical properties of aggregates – Part 2 Methods for determination of resistance to fragmentation
DIN EN 1097-5:1999	Testing for mechanical and physical properties of aggregates - Part 5:Determination of water content by drying in a ventilated oven
DIN 52105	Compressive strength of crushed rock
NF P 18542:1994	Conventional natural aggregates for hydraulic concrete- Aggregate qualification criteria vis- a-vis the alkali reaction
Mixing water	
Chemical admixtures	
DIN EN 480-10:1996	Admixtures for concrete, mortar and grout - test methods – Part 10: Determination of water soluble chloride content
DIN EN 480-12:1997	Admixtures for concrete, mortar and grout - test methods - Part 12: Determination of the alkali content of admixtures
Concrete	
German Society of Concrete and Construction TechnologyDBV-1996""	Concrete for massive structures
German Society of Concrete and Construction TechnologyDBV-1996""	Water resistant structure members made of concrete

NAGA HAMMADI BARRAGE JV

A joint venture between Vinci Construction Grands Projets / Bilfinger Berger AG / Orascom Construction Industries

Naga Hammadi, 07 July 2004
NH01/NHBDC/T/01458

Naga Hammadi Barrage Development Consultants
26A Asma Fahmy Street,
Mirghany, Heliopolis,
Cairo, Arab Republic of Egypt

Attn.: Chief Resident Engineer, B. R. Hein
Naga Hammadi Barrage Site Office

Distribution: NHBDC Site 1 original, Cairo 1 copy
Employer/ PIU, RE 1 copy, Dep. RE 1 copy

Dear Sir,

RE.: Permanent Cut-Off Wall – Plastic Concrete – ASR.

Standard testing methods such as AFNOR P 18-454 or ASTM C 227-03 assess the susceptibility of cement and aggregate mixes to expansion by checking the increase in length of concrete or mortar bars.

The very nature of the plastic concrete to be used for the construction of the permanent cut-off wall does not permit the use of such methods.

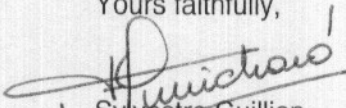
To address this issue of the possible risk of Alkali Silica Reactivity, we have therefore approached Mr. André Le Roux to request his opinion as an independent expert over this matter.

Mr. André Le Roux was the leader for the development of ASR French standards and wrote the French reference document "Recommendations for prevention of damage by the alkali-aggregate reaction".

Please find enclosed for your review, comments and records the following documents:

- 1) The expert opinion from Mr. A. Le Roux.
- 2) The CV of Mr. A. Le Roux.

Yours faithfully,


Sylvestre Guillien
Project Manager

FG

Encl.: as above detailed.

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Materials Consult International

Matériaux Conseil International

Paris le 23 Juin 2004

André Le Roux
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78330 Fontenay le Fleury
Tel. : 01 30 45 46 51 / 02 96 74 03 76 / 06 15 05 05 53
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VINCI Construction Grands Projets
A l'attention de **Monsieur Lionel Linger**
5 cours Ferdinand de Lesseps
92851 Rueil Malmaison Cedex

V/réf. : Email du 10/03/04
N/Réf. : Proposition N° 164 06 04

Objet : New Naga Hammadi dam
ASR in the plastic concrete

Dear Sir,

Please find hereafter my point of view about the plastic concrete and the risk of Alkali Silica Reactivity in this type of concrete formula. In the present case, the aggregates are potentially reactive, the concrete has a very low Young modulus associated with a high content of water adsorbed at the surface of bentonite thin sheets. In the pore solution, hydroxyl (OH^-) and alkalis (Na^+) could be in a sufficient concentration to initiate a chemical attack. This attack gives a product of reaction like a gel, which will take place in the pores filled with water of this kind of concrete.

However the plastic character of this type of concrete (low Young modulus), and its high content of water adsorbed at the surface of bentonite thin sheets, inhibits the mechanical effect such as the formation and development of harmful network of cracks, so ASR in this type of concrete will not affect the characteristics of the concrete.

Considering that it is important to verify that this concrete does not become an external source of alkalis for the concrete of the main structure, it can be assumed that the presence of bentonite in the mix composition will result in a very impermeable material behaviour for the sealing element. Consequently, a transport of alkalis by water, out of external sources could not be considered as deleterious.

Best regards

Dr André Le Roux

Plastic Concrete

Question: May the plastic concrete develop harmful ASR ?

1] Plastic concrete composition

➤ Information about the plastic concrete mix

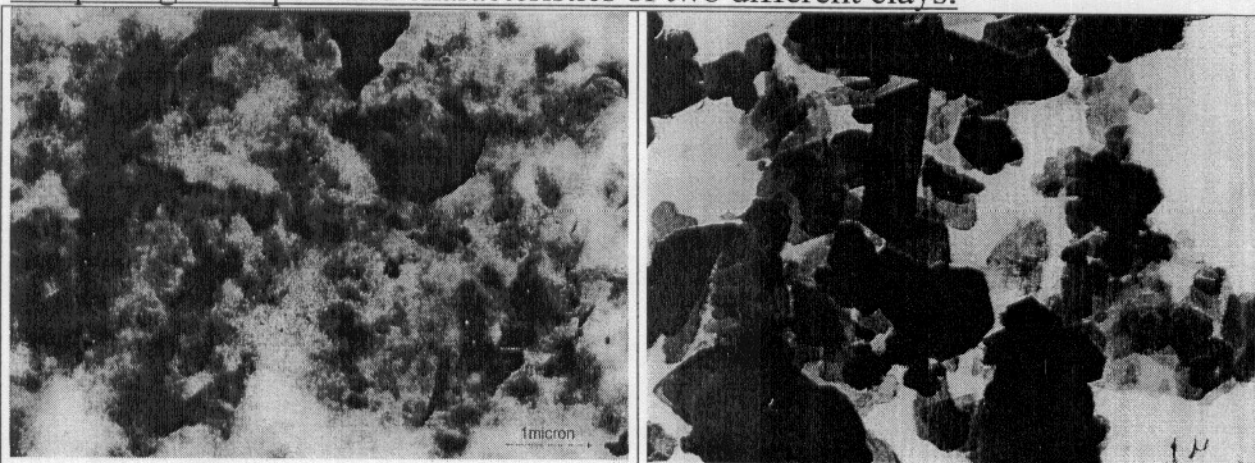
CEM I 42,5 R (0,52 % alkali)	136 kg/m ³
Bentonite (3,94 % alkali)	35 kg/m ³
Sand 0/4 HIW (0,0013 % alkali)	821 kg/m ³
Coarse aggregate BALABISH BAHARI (0,0049 % alkali)	671 kg/m ³
Water	380 kg/m ³

▶ water /cement = 2,8

➤ Some further information about bentonite clays

Bentonite is a sodic montmorillonitic clay. This type of clays have particular physico-chemical properties.

Morphological aspect and characteristics of two different clays:



Bentonite 1cm= 1μm

Kaolinite other type of clay

Main physico-chemical characteristics

0,005 to 1 μm	Particle	0,5 to 4 μm
80 to 110	CEC meq g/100g	5 to 15
600 to 800 m ² /g	Specific area	<15 m ² /g
Yes	Thixotropic properties	No

Structural formula:



- The dimension of elementary particle is often less than $1\mu\text{m}$, and the structure where some Al^{+3} and Si^{+4} in tetrahedral position and also where Mg^{+2} and Al^{+3} in octahedral position are partially substituted gives a particular behaviour.
- Very important CEC (cation exchange capacity): 90 to 120 meq g/100g.
- Very important specific area (600 to $800 \text{ m}^2/\text{g}$).
- Thixotropic properties.
- Easily removable, all alkalis (Na^+) presents in the structure of the clay must be considered active in the pore solution of the concrete.

Bentonite is characterized by a very important water absorption $\rightarrow$ competition between clay and cement during the initial hydration phase $\rightarrow$ plastic concrete: water = $380\text{kg}/\text{m}^3 \rightarrow$ **concrete with a very high content of water adsorbed at the surface of bentonite thin sheets.**

In this kind of concrete the cement has, with bentonite clay, two successive actions:

- Firstly, the clay structure is modified: Ca^{++} replaces original Na^+ in the structure of the clay. $\rightarrow$ The concrete pore solution became more sodic;
- Secondly, the clay structure is progressively degraded giving new minerals (hydrated calcium aluminates and silicates).

2] Origin of ASR degradations

➤ **Alkali Silica Reactions** are chemical reactions between reactive forms of silica present in the aggregates and OH^- associated with alkalis present in the pore solution of the concrete. The presence of four conditions is imperative to develop deleterious ASR in concrete:

- 1- Reactive form of silica: **The coarse aggregates used in the plastic concrete are potentially reactive (PR).**
- 2- Alkalis in sufficient quantity: concerning alkali in the pore solution, it is important to determine alkali released by bentonite. All alkali present in the structure of the clay are active in the medium. The percentage and the type of alkalis (Na^+) is classical for this type of clays. **The global amount**

of alkalis ($\text{Na}_2\text{O}_{\text{eq}}$) calculated in the plastic concrete gives a value of $2,5 \text{ kg/m}^3$, which is inferior to the 3 kg/m^3 of $\text{Na}_2\text{O}_{\text{eq}}$ considered being the potentially deleterious limit of alkalis in the concrete mix.

- 3- A large quantity of water is required to give a reaction gel. Water is present in large quantity in this type of concrete.

Mass / m^3	Concrete constituents	Na_2O equiv kg/m^3
821 kg	sand 0,0013%	0,010
671 kg	coarse aggregates	0, 033
136 kg	Cement CEMI 42,5 R (0,52% Alk)	0,707
35 kg	bentonitic clay (3,94% Alk Eq)	1,379
380 kg	Water	Max, 0,380
2051 kg	TOTAL	2,5
w/c ratio	2,8	

- 4- The damages (networks of multi cracks) caused by alkali silica reaction can be observed only if the concrete has initially good mechanicals characteristics and compact structure. According to its low Young modulus value and its high content of water adsorbed at the surface of bentonite thin sheets, **plastic concrete does not comply with this case.**

3] Is the concrete performance test or any other test for potential alkali reactivity of cement aggregates combinations suitable to detect a potential reactivity of such a mixture ?

All tests, AFNOR P 18-454, ASTM C 227-03 , assess the susceptibility of cement aggregates combinations to expansive reaction by measurement of an increase in length of concrete or mortar bars.

Concerning the plastic concrete, two conditions are fulfilled:

- Coarse aggregates are potentially reactive,
- Water is widely abundant.

The alkalis ($\text{Na}_2\text{O}_{\text{eq}}$) and especially Na^+ are present and mobile in the pore solution with a concentration inferior to 3 kg/m^3 .

On another hand the ultimate condition corresponding to a concrete with a compact and dense structure is not fulfilled.

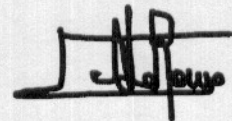
In this kind of plastic concrete, the gel produced by the reaction can fill the soft cement/bentonite paste and no cracks are consequently visible. As a matter of fact, the test cannot measure a swelling due to alkali reaction cracks.

3] Conclusion

In a concrete formulated with potentially reactive aggregates, the cracks due to the alkali silica reaction generally affect concrete with a significant Young modulus and strength. In the present case, due to the use of PR aggregate, a chemical attack by alkalis can not be rejected. On another hand, this attack gives a product of reaction like a gel, which will take place in the pores filled with water of this kind of concrete. The plastic character of this type of concrete (low Young modulus), and its high content of water adsorbed at the surface of bentonite thin sheets, inhibits the mechanical effect such as the formation and development of harmful network of cracks.

Consequently, I believe that even if an alkali-silica reaction could occur in this type of concrete, it will not affect the final properties of the concrete.

Dr A. Le Roux



NAGA HAMMADI BARRAGE DEVELOPMENT CONSULTANTS

Rec. Taha
04-08-04

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Germany

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Engineering
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NHBDC/RGBS/L1/00379
Eng. Mohammed Abd El Aal
Resident Engineer
RGBS – Site
Naga Hammadi Barrage

03 August 2004

New Naga Hammadi Barrage and Hydropower Plant Lot 1 - Civil Works

Subject: Permanent Cut-Off Wall – Plastic Concrete – ASR

References:

(1)	NHBJV's Doc.	NH01-P-02-JV-RPT-1006-B
(3)	Our letter Ref.	NHBDC/NHJV/L1/755 dated 06 September 2003
(3)	Our letter Ref.	NHBDC/NHJV/L1/0806 dated 23 September 2003
(4)	Our letter Ref.	NHBDC/NHJV/L1/01187 dated 07 March 2004
(5)	Our letter Ref.	NHBDC/NHJV/L1/01363 dated 20 June 2004
(6)	NHBJV's Ref.	NH01/NHBDC/T/01458 dated 07 July 2004
(7)	NHBJV's Ref.	NH01/NHBDC/T/01479 dated 21 July 2004
(8)	NHBJV's Ref.	NH01/NHBDC/T/01491 dated 29 July 2004

Dear Engineer Mohammed Abd El Aal,

We refer to the mix design for the plastic concrete of the permanent cut-off wall. The Plastic Concrete Mixture M1 as proposed by the Contractor's document (1) was selected by our Ref. (2) and its suitability was confirmed by Ref. (3). By our correspondence (4) we requested the Contractor to arrange for testing of this mix M1 with regard to alkali-silica reactivity. The Contractor replied to our request by sending letter (6) with a related expert opinion and CV of Mr. Le Roux attached and explaining that the relevant test methods are applicable only for dense concrete, but not for plastic concrete with its high w/c-content and bentonite component.

We have sent a copy of Mr. Le Roux' expert opinion to Dr. Siebel, who is heading the Department for Concrete Technology at the FIZ in Düsseldorf, Germany. We had selected the FIZ as independent laboratory for spot-checking of results obtained by CEBTP, and we had requested the Contractor to arrange for these spot-checking tests by our Ref. (5). We have received today Dr. Siebel's attached response confirming that he is in full agreement with Mr. Le Roux' opinion.

Based on the above we have concluded that the use of the selected Plastic Concrete Mixture M1 is acceptable for the permanent cut-off wall, provided that by routine testing it is regularly verified, that the total alkali-equivalent content of the mix does not exceed 2.7 kg/m^3 . This is 10% less than the 3 kg/m^3 , which both experts, Le Roux and Dr. Siebel, consider as the potentially deleterious limit of alkalis in the concrete mix. The reduction by 10% does provide sufficient safety margin for remaining uncertainties. The related ITP submitted for approval by JV's Ref. (7) will have to be amended by the requirement for related routine testing, which we will stipulate in our approval notes currently under preparation.

Thus, the possibility that alkali silica reactions could occur in the permanent cut-off wall made by using Plastic Concrete Mixture M1 with an alkali-equivalent content of less than 2.7 kg/m^3 is deemed to be very low. On the other side, even if an alkali silica reaction would take place, then it would not be deleterious, because of the very high water-cement ratio of mix M1 ($w/c = 2.8$, resulting from 380 kg/m^3 of water in the mix). This high w/c leads to a comparatively high porosity, due to large quantities of excess water. Consequently, there is sufficient pore volume available in the plastic concrete to accommodate the gel-like reaction products of an unlikely alkali silica reaction, without causing any cracks, and correspondingly without affecting the mechanical properties of the concrete. (This phenomenon is described in more details by the reports attached to the Contractor's letters (6) and (8).)

In our opinion, there is now no further basis for any doubts regarding the use of Plastic Concrete Mixture M1 for the permanent cut-off wall, subject to regular verification of compliance with the a/m limit for the total alkali-equivalent content stipulated above. This will have to be incorporated into the related ITP. We assume that you concur with our opinion, and we will proceed accordingly, unless we hear from you otherwise until the end of this week.

Should you wish to further discuss this matter, our Dr. Schmidt will be ready at any time.

Yours Sincerely,



B. R. Hein
Chief Resident Engineer

cc: NHBDC-Cairo: Dr. J. Kohli, PM

TE

Encl. (1): FIZ letter on Expert Opinion of Mr. Le Roux, Ref. BTe/Sb-Esc, dated 02.08.2004



Verein Deutscher Zementwerke e.V.
Forschungsinstitut der Zementindustrie

Verein Deutscher Zementwerke e.V., Postfach 301063 D-40410 Düsseldorf

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Ihr Zeichen	Ihr Schreiben vom	Ihrer Zeichen	Durchwahl	Datum
		BTe/Sb-Esc	4578-222	02.08.2004

Expert Opinion of Mr. Le Roux

Dear Dr. Schmidt,

Lahmeyer International GmbH sent us the expert opinion of Mr. Le Roux (letter from 23. June 2004) and asked for our opinion.

We fully agree with Mr. Le Roux. If an aggregate is only potentially reactive an alkali-content (Na_2O -eq.) of less than 3 kg/m^3 would not lead to an harmful ASR. Even if there will occur a reaction it could not affect the properties of the hardened concrete because the elastic modulus of this concrete is very low.

Sincerely

VEREIN DEUTSCHER ZEMENTWERKE e.V.
FORSCHUNGSINSTITUT DER ZEMENTINDUSTRIE
Abteilung Betontechnik

Dr.-Ing. E. Siebel

I. A. Dipl.-Ing. E. Eickschen

3/8/04

NHBDC	
- 3 AUG 2004	
7.14	
COPY (RS)	T.E.

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Dresdner Bank
Düsseldorf 0210 020 400
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USt-IdNr.: DE 119353748 Steuer-Nr.: 105/5894/1227

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Angewandt: 02.08.2004 15:00

MEMORANDUM

Naga Hammadi, 02.03.2004

To: Mr. B. Hein (CRE NHBDC)
cc: Dr. J. Kohli (PM NHBDC)
From: Dr. R. Schmidt

Naga Hammadi Barrage Concrete Ingredients: Alkali-Reactivity of Aggregates

A. Cause

For the a/m project, huge quantities of reinforced mass concrete are required to be executed, starting from the end of this year. During site inspection on 01.03.2004, the Contractor has informed NHBDC verbally that all investigated types of gravel available in the area have been found to be deleterious as with regards to alkali-reactivity.

Note: As documented by the attached extracts from the Bureau of Reclamation/Concrete Manual, alkali-reactivity is a very serious issue which could lead to unrepairable damage of concrete. There, it is considered crucial for the success of the project that this issue is followed very closely and with particular attention by all parties involved.

B. Codes

PTS Section 5.4.1.2 prescribes the following relevant code for testing:

- **ASTM C 227** Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)

The relevant German DIN regulations require involvement of special expertises and laboratories, in case of any doubts, and in order to adequately address this critical issue.

Other related ASTM codes, which are presumably less suitable, are:

- **ASTM C 289** Test Method for potential reactivity of aggregates
- **ASTM C 1260** Portland Alkali Reactivity of Aggregates (Mortar-Bar Method)

The Contractor has proposed to use French code NF-P 18-542. Since this code has not yet been accepted, any results would be only informative, but will not necessarily form the basis for approval of using any aggregates tested in accordance with this code.

(Dr. R. Schmidt)



Figure 4.—Typical pattern cracking on the exposed surface of concrete affected by alkali-aggregate action. PX-D-32049.

micrometers (macroscopic), provides relief for pressures developed by free water as it freezes and expands.

(b) Resistance to Chemical Deterioration.—Concrete deterioration, attributable in whole or in part to chemical reactions between alkalis in cement and mineral constituents of concrete aggregates, is characterized by the following observable conditions: (1) Cracking, usually of random pattern on a fairly large scale (see fig. 4); (2) excessive internal and overall expansion; (3) cracks that may be very large at the concrete

surfaces (openings up to 1½ inches have been observed) but which extend into the concrete only a distance of from 6 to 18 inches; (4) gelatinous exudations and whitish amorphous deposits, on the surface or within the mass of the concrete, especially in voids and adjacent to some affected pieces of aggregate; (5) peripheral zones of reactivity, alteration, or infiltration in the aggregate particles, particularly those particles containing opal and certain types of acid and intermediate volcanic rocks; and (6) lifeless, chalky appearance of the freshly fractured concrete.

Deterioration of concrete also results from contact with certain chemical agents. The chemical action of a number of substances on unprotected concrete is shown in table 1. The table is intended to provide general guidance only, and salts listed as having no action might be aggressive at high concentrations or at high temperatures. Attack may assume one of several forms:

(1) Erosion of concrete results from the formation of soluble products which are removed by leaching. Attack by organic and inorganic acids is in this class. Attack by acids is seldom encountered at sites of Bureau work. This is a fortunate circumstance because no type of portland cement offers resistance to the forms of acid corrosion listed in table 1. Where likelihood of acid corrosion is in-

Table 1.—Effects of various substances on hardened concrete

Substance	Effect on unprotected concrete
Petroleum oils, heavy, light, and volatile	None.
Coal-tar distillates	None, or very slight.
Inorganic acids	Disintegration.
Organic materials:	
Acetic acid	Slow disintegration.
Oxalic and dry carbonic acids	None.
Carbonic acid in water	Slow attack.
Lactic and tannic acids	Do.
Vegetable oils	Slight or very slight attack.
Inorganic salts:	
Sulfates of calcium, sodium, magnesium, potassium, aluminum, iron	Active attack.
Chlorides of sodium, potassium	None.
Chlorides of magnesium, calcium	Slight attack.
Miscellaneous:	
Milk	Slow attack.
Silage juices	Do.
Molasses, corn syrup, and glucose	Slight attack.
Hot distilled water	Rapid disintegration.

1/3

17. Classification and Use of Pozzolans.—Pozzolans are siliceous or siliceous and aluminous materials which in themselves possess little or no cementitious value but will chemically react, in finely divided form and in the presence of moisture, with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

All pozzolans owe their chemical activity to one or more of five kinds of substances: (1) siliceous and aluminous, artificial or natural glass; (2) opal; (3) calcined clay minerals; (4) certain zeolites; and (5) hydrated oxides and hydroxides of aluminum. They can be classified petrographically as follows:

- (1) Clays and shales (must be calcined to activate).
 - Kaolinite type
 - Montmorillonite type
 - Illite type
- (2) Opaline materials (calcination may or may not be required).
 - Diatomaceous earth
 - Opaline cherts and shales
- (3) Volcanic tuffs and pumicites (calcination may or may not be required).
 - Rhyolitic types
 - Andesitic types
 - Phonolitic types
- (4) Industrial byproducts.
 - Ground brick
 - Fly ash
 - Silica fume

Pozzolans are normally not specified for concrete unless advantages in their use outweigh the disadvantages of storing and handling an extra material. Pozzolans may be used to improve the workability and quality of concrete, to effect economy, or to protect against disruptive expansion caused by the reaction between certain aggregates and the alkalis in cement. Most good quality pozzolans also increase the resistance of concrete to deterioration in exposure to soluble sulfates in soil or ground water. Fly ash is more effective and consistent for this purpose than the natural types. In addition to improving workability of concrete, most pozzolans will reduce heat generation, thermal volume change, bleeding, and permeability of concrete.

The following pozzolans are known to control alkali-aggregate reaction effectively, even when reactive aggregate and high-alkali cement are used:

- (1) Highly opaline material, such as diatomaceous earth and opaline chert.
- (2) Certain volcanic glasses.
- (3) Certain calcined clays.
- (4) Fly ash.

All the materials listed here reduce expansion caused by alkali-aggregate reaction, with fly ash being generally the least effective. However, the effectiveness of these pozzolans in controlling disruptive alkali-aggregate expansion is generally diminished if calcium chloride is added to the mix.

Pozzolans that will control alkali-aggregate reaction can be divided into two groups: (1) certain amorphous siliceous and aluminous substances; and (2) certain calcined montmorillonite-type clays. Materials of the first group include opal and highly opaline rocks of any type; kaolin clays calcined in the range 1,200° to 1,800° F; diatomaceous earth; some rhyolitic pumicites; and some artificial siliceous glasses. Fly ashes as a group are moderately effective in reduction of reactive expansion when compared to the better materials of groups (1) and (2); however, some fly ashes significantly reduce expansion. Calcined clays of the montmorillonite group often are effective in controlling alkali-aggregate reaction. Calcination at 1,600° F or higher is necessary for these materials to avoid causing excessive water requirement, shrinkage cracking, or abnormal stiffening of a concrete mix.

Some pozzolans appreciably increase the water requirements of concrete when used in sufficient quantity to control alkali-aggregate reaction. These materials include diatomaceous earth, several industrial byproducts composed of amorphous hydrous silica, and some of the clayey pozzolans. The increase in water requirement with pozzolans results from their high absorption, low specific gravity, and in some cases high fineness. Fly ash, of low carbon content, generally decreases the water requirement.

Caution must be exercised in the selection and use of pozzolans, as their properties vary widely and some may introduce adverse qualities into the concrete, such as excessive drying shrinkage and reduced strength and durability. Moreover, when used in insufficient proportions with some chemically reactive aggregate-cement combinations, certain pozzolans have increased the expansion in mortars. Before accepting a pozzolan for a specific job, it is advisable to test it in combination with the cement and aggregate to be used, so as to determine accurately the advantages or disadvantages of the pozzolan with respect to quality and economy of the concrete. Any pozzolan proposed for use in Bureau construction must meet the requirements of Federal Specification SS-C-1960/5, Pozzolan For Use in Portland Cement Concrete.

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Chemical soundness of an aggregate is also important. In many instances, excessive expansion causing premature deterioration of concrete has been associated with chemical reaction between reactive aggregate and the alkalis in cement. Known reactive substances are the silica minerals, opal, chalcedony, tridymite, and cristobalite; zeolite, heulandite (and probably ptilolite); glassy to cryptocrystalline rhyolites, dacites and andesites and their tuffs; and certain phyllites. Any rock containing a significant proportion of reactive substances will be deleteriously reactive; thus, although pure limestones and dolomites are not deleteriously reactive, limestones and dolomites that contain opal and chalcedony are related to deterioration of concrete as a result of alkali-aggregate reactivity. Similarly, normally innocuous sandstone, shales, granites, basalts, or other rocks can be deleteriously reactive if they are impregnated or coated with opal, chalcedony, or other reactive substances.

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(c) *Chemical Suitability of Aggregates*.—Some aggregate materials undergo chemical changes that may possibly be beneficial but are often definitely injurious. Such reactions may be of different kinds, including reaction between aggregate material and the constituents of cement, solution of soluble materials, oxidation by weathering, and complicated processes that impede the normal hydration of cement. Volume changes of clays by absorption and dehydration are physical changes which may be considered under this topic because of their relation to the crystallographic structure and chemical composition of different clay minerals.

Reaction between certain aggregate materials and the alkalis in cement is associated with expansion, cracking, and deterioration of concrete. Small amounts of opal, rhyolites, and certain other rocks and minerals in aggregates that are otherwise unobjectionable have caused excessive expansion and rapid deterioration. Opal (amorphous, hydrous silica) is the most reactive constituent in aggregates, but the acidic and intermediate volcanic rocks are the most significant because they are most numerous.

Rocks and minerals known to react deleteriously with cement alkalis are volcanic rocks of medium to high silica content; silicate glasses (artificial or natural excluding the basic type such as basaltic glass); opaline and chalcedonic rocks (including most cherts and flints); some phyllites, tridymite, and certain zeolites. In general, aggregates petrographically similar to known reactive types, or which on the basis of service history or laboratory experiment are suspected of reactive tendencies, should be used only with cement that is low in alkalis. Such reactions are reduced in intensity, and probably eliminated in some instances, by the limitation of the alkalis (Na_2O plus $0.658 \text{ K}_2\text{O}$) to 0.5 to 0.6 percent of the cement and/or the use of an effective pozzolan.

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Petrographic examination aids the interpretation of physical and chemical tests of aggregates and may disclose weaknesses not discovered by standard physical tests. Aggregate is visually examined and identified according to mineralogical and chemical differences. The extent to which the particles are coated, the nature of the coating substance, and particle shape are determined. Potential deleterious reactivity of aggregates with cement alkalis may be detected, and, when sufficient time is available, the reactivity of the aggregates may be checked by a chemical test devised in the Denver laboratories.

Following petrographic examination, if the mortar bar test for potential alkali-aggregate reactivity is recommended, concrete aggregates are tested in 1- by 1- by 1 1/4-inch mortar bars made with Bureau standard high- and low-alkali cements. To establish the existence of the pessimum condition in which smaller percentages of reactive aggregates may produce increased expansion, the aggregates, including both sand and coarse aggregate crushed to sand sizes, are tested in amounts of 25, 50, and 100 percent with high-alkali cements only. Neutral quartz also crushed to sand sizes in amounts of 75, 50, and 0 percent, respectively, constitutes the remainder of the aggregate. If any of these combinations results in expansions equal to or greater than those described immediately hereafter, the aggregate is considered to be reactive and the recommended precautions should be taken in its use. The low-alkali cement is used in some bars in lieu of high-alkali cement to establish whether expansions other than those caused by alkali-aggregate reactions will occur. Reactivity of the aggregate can thus be definitely established, and effectiveness of using low-alkali cement can be determined.

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Results of the mortar bar tests have been correlated with rate and magnitude of deterioration caused by alkali-aggregate reaction in field structures. It has been established that any combination of aggregate and standard high-alkali cement causing a mortar expansion in excess of 0.20 percent linearly in 1 year will produce readily recognizable expansive deterioration of concrete through alkali-aggregate reaction. Aggregates that cause an expansion of less than 0.10 percent in 1 year when used with standard high-alkali cement have been found to be innocuous so far as alkali-aggregate reactivity is concerned. Aggregates causing an expansion in the range of 0.10 and 0.20 within 1 year when used with high-alkali cement do not show clear-cut evidence of this reaction; but several aggregates in this category are associated with concrete deterioration, the cause of which is conjectural. Consequently, these aggregates should be used only with low-alkali cement or a suitable combination of portland cement and pozzolan.

3/3

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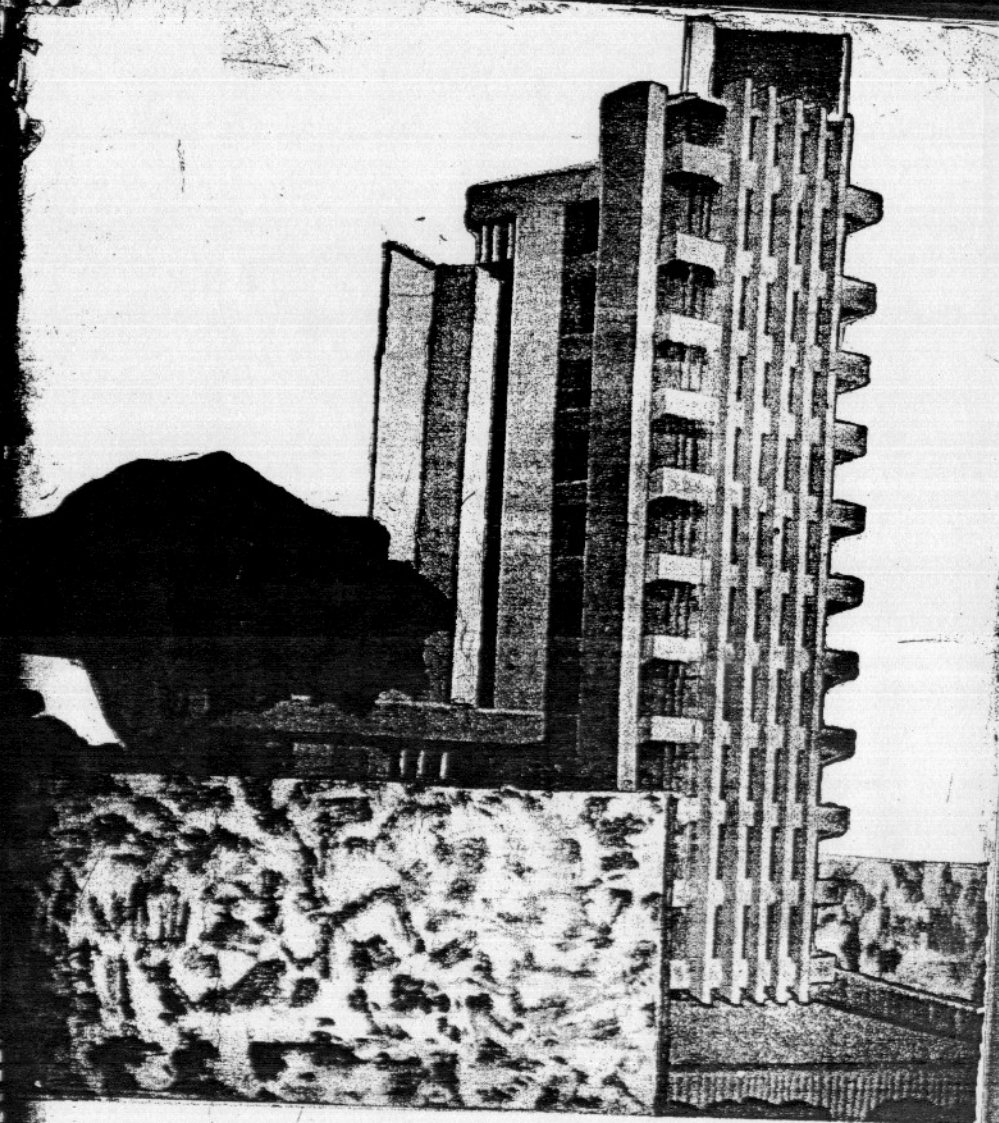
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TECHNOLOGY

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CONCRETE TECHNOLOGY

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It may be pointed out that the sulphate soundness test might be used to accept aggregates but not to reject them, the assumption being that aggregates which will satisfactorily withstand the test are good while those which breakdown may or may not be bad. Unfortunately, the test is not reliable. Certain aggregates with extremely fine pore structure show almost no loss of weight. Conversely, certain aggregates that disintegrate readily in the sulphate test but produce concrete of high resistance to freezing and thawing. A low loss of weight usually, but not always, an evidence of good durability, whereas a high loss of weight places the aggregate in questionable category.

Alkali Aggregate Reaction

For a long time aggregates have been considered as inert materials but later on, particularly, after 1940's it was clearly brought out that the aggregates are not fully inert. Some of the aggregates contain reactive silica, which reacts with alkalis present in cement i.e. sodium oxide and potassium oxide.

In the United States of America it was found for the first time that many failures of concrete structures like pavement, piers and sea walls could be attributed to the alkali-aggregate reaction. Since then a systematic study has been made in this regard and now it is proved beyond doubt that certain types of reactive aggregates are responsible for promoting alkali-aggregate reaction.

The types of rocks which contain reactive constituents include traps, andesites, rhyolites, siliceous limestones and certain types of sand stones. The reactive constituents may be in the form of opals, cherts, chalcedony, volcanic glass, zeolites etc. The reaction starts with attack on the reactive siliceous minerals in the aggregate by the alkaline hydroxide derived from the alkalis in cement. As a result, the alkali silicate gels of unlimited swelling type are formed. When the conditions are congenial, progressive manifestation by swelling takes place, which results in disruption of concrete with the spreading of pattern cracks and eventual failure of concrete structures. The rate of deterioration may be slow or fast depending upon the conditions. There were cases where concrete has become unserviceable in about a year's time. In India, the basalt rocks occurring in the Deccan plateau, Madhya Pradesh, Kathiawar, Hyderabad, Punjal Hill (Jammu and Kashmir), Bengal and Bihar should be viewed with caution^{3,5}.

Similarly, limestones and dolomites containing chert nodules would be highly reactive. Indian limestones of Bijawar series are known to be highly cherty. Regions of occurrence include Madhya Pradesh, Rajasthan, Punjab and Assam.

Sandstones containing silica minerals like chalcedony, crypto to microcrystalline quartz or opal are found to be reactive. Regions of occurrence include Madhya Pradesh, Bengal, Bihar and Delhi. Some of the samples obtained from Madhya Pradesh, West Bengal and Kashmir were found to be containing reactive constituents which could be identified by visual examination. These contain substantial quantities of minerals like opals, chalcedony and amorphous silica. Quartzite samples of rock obtained from Kashmir were also found to be highly reactive.

Geographically India has a very extensive deposit of volcanic rocks. The Deccan traps covering the western part of Maharashtra and Madhya Pradesh, the dolomites of Madhya Pradesh, Punjab and Rajasthan, limestones of Jammu and Kashmir would form extensive source of aggregate for concrete construction. The aggregates from these rocks should be studied cautiously to see how far reactive are they. It is interesting to note that only such aggregates which contain reactive silica in particular proportion and in particular fineness are found to exhibit tendencies for alkali-aggregate reaction. It is possible to reduce its tendency by altering either the proportion of reactive silica or its fineness.

Factors Promoting the Alkali-Aggregate Reaction

- (i) Reactive type of aggregate ✓
- (ii) High alkali content in cement ✓
- (iii) Availability of moisture ✓
- (iv) Optimum temperature conditions. ✓

It is not easy to determine the potential reactivity of the aggregates. The case history of aggregates may be of value in judging whether a particular source of aggregate is deleterious or harmless. The petrographic examination of thin rock sections may also immensely help to assess the potential reactivity of

the aggregate. This test often requires to be supplemented by other tests.

Mortar Bar Expansion Test devised by Stanton has proved to be a very reliable test in assessing the reactivity or otherwise of the aggregate. A specimen of size 25 mm × 25 mm and 250 mm length is cast, cured and stored in a standard manner as specified in IS : 2386 (Part VII 1963). Measure the length of the specimens periodically, at the ages of 1, 2, 3, 6, 9 & 12 months. Find out the difference in the length of the specimen to the nearest 0.001 per cent and record the expansion of the specimen. The aggregate under test is considered harmful if it expands more than 0.05 per cent after 3 months or more than 0.1 per cent after six months.

The potential reactivity of aggregate can also be found out by chemical method. In this method the potential reactivity of an aggregate with alkalis in Portland cement is indicated by the amount of reaction taking place during 24 hours at 80°C between Sodium hydroxide solution and the aggregate that has been crushed and sieved to pass a 300 micron IS Sieve and retained on 150 micron IS Sieve. The solution after 24 hours is analysed for silica dissolved and reduction in alkalinity, both expressed as millimoles per litre. The values are plotted as shown in Fig. 3.3 reproduced from IS : 2386 (Part VII 1963). Generally, a potentially deleterious reaction is indicated if the plotted test result falls to the right of the boundary line of Fig 3.3 and if plotted result falls to the left side of the boundary line, the aggregate may be considered as innocuous. The above chemical test may also be employed for finding out the effectiveness of adding a particular proportion of pozzolanic material to offset the alkali-aggregate reaction. Table 3.6 shows dissolved silica and reduction in alkalinity of some Indian aggregates.

High Alkali Content in Cement

The high alkali content in cement is one of the most important factors contributing to the alkali-aggregate reaction. Since the time of recognition of the importance of alkali-aggregate reaction phenomena, a serious view has been taken on the alkali content of cement. Many specifications restrict

the alkali content to less than 0.6 per cent expressed as soda equivalent, A cement, meeting this specification is designated as a low alkali cement. Field experience has never detected serious deterioration of concrete through the process of alkali-aggregate reaction when cement contained alkalis less than 0.6 per cent. In exceptional cases, however, cement with even lower alkali content have caused objectionable expansion. Generally, Indian cements do not contain high alkalis as in U.S.A. and U.K. The result of investigations done to find out the alkali content in the sample of Indian cement is shown in Table 3.7. Table 3.7 shows that 11 out of 26 Indian cement samples have total alkali content higher than 0.6 per cent.

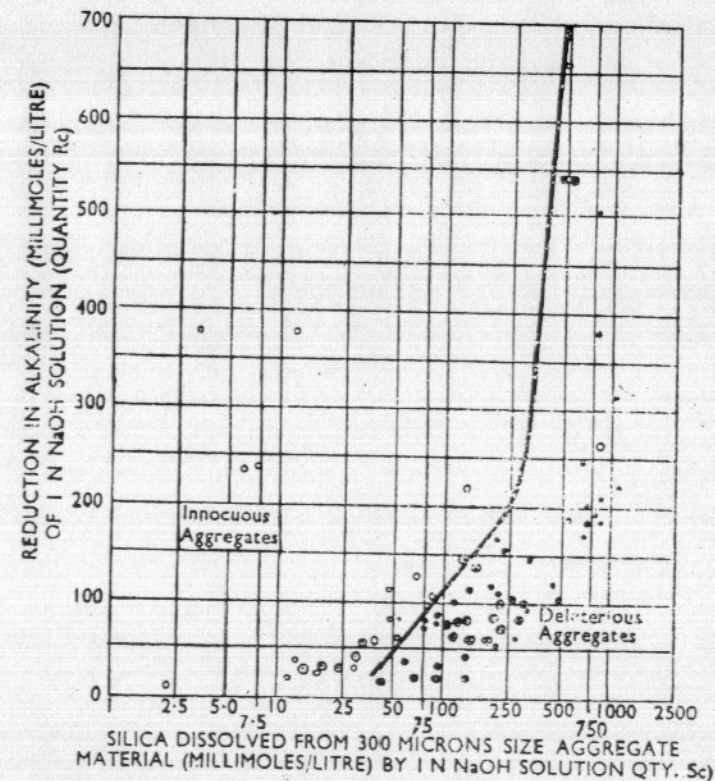


Fig. 3.3 Illustration of division between innocuous and deleterious aggregates on basis of reduction in alkalinity test.

increase in volume. Many destructive forces become operative on the concrete disrupted by alkali aggregate reaction which will further hasten the total disintegration of concrete.

Control of Alkali-Aggregate Reaction

From the foregoing discussion (it is) apparent that alkali-aggregate reaction can be controlled by the following methods:

- (i) Selection of non-reactive aggregates
- (ii) By the use of low alkali cement
- (i.i) By the use of corrective admixtures such as pozzolanas
- (iv) By controlling the void space in concrete
- (v) By controlling moisture condition and temperature.

It has been discussed that it is possible to identify potentially reactive aggregate by petrographic examination, mortar bar test or by chemical method. Avoiding the use of the reactive aggregate is one of the sure methods to inhibit the alkali-aggregate reaction in concrete.

In case avoidance of suspicious reactive aggregate is not possible due to economic reasons, the possibility of alkali-aggregate reaction can be avoided by the use of low alkali cement. Restricting the alkali content in cement to less than 0.6 per cent or possibly less than 0.4 per cent, is another good step.

It has been pointed out earlier that generally the aggregate is found to be reactive when it contains silica in a particular proportion and in particular fineness. It has been seen in the laboratory that if this optimum condition of silica being in particular proportion and fineness is disturbed, the aggregate will turn to be innocuous. This disturbance of optimum content and fineness of silica can be disturbed by the addition of pozzolanic materials such as crushed stone dust, diatomaceous earth, fly ash or surkhi. The use of pozzolanic mixture has been found to be one of the practical solutions for inhibiting alkali-aggregate reaction.

It has been said that development of osmotic pressure on the set-cement gel by the subsequently formed alkali-silica gel is responsible for the disruption of concrete. If a system is introduced to absorb this osmotic pressure, it is probable that the disruption could be reduced. The use of air-entraining agent has frequently been recommended as a means of absor-

bing the osmotic pressure and controlling expansion due to alkali-aggregate reaction in mortar and concrete.

For the growth of silica gel a continuous availability of water is one of the requirements. If such continuous supply is not made available, the growth of silica gel is reduced. Similarly, if the correct range of temperature is not provided, the extent of expansion is also reduced.

Thermal Properties

Rock and aggregate possesses three thermal properties which are significant in establishing the quality of aggregate for concrete construction. They are:—

- (i) Coefficient of expansion
- (ii) Specific heat
- (iii) Thermal conductivity.

Out of these, specific heat and conductivity are found to be important only in mass concrete construction where rigorous control of temperature is necessary. Also these properties are of consequence in case of light weight concrete used for insulation purpose. When we are dealing with the aggregate in general it will be sufficient at this stage to deal with only the coefficient of expansion of the aggregate, since it interacts with the coefficient of thermal expansion of cement paste in the body of the set-concrete.

An average value of the linear thermal coefficient of expansion of concrete may be taken as 9.9×10^{-6} per °C, but the range may be from about 5.8×10^{-6} per °C to 14×10^{-6} per °C depending upon the type and quantities of the aggregates, the mix proportions and other factors. The range of coefficient of thermal expansion for hydrated cement paste may vary from 10.8×10^{-6} per °C to 16.2×10^{-6} per °C. Similarly, for mortar it may range from 7.9×10^{-6} per °C to 12.6×10^{-6} per °C.

The linear thermal coefficient of expansion of common rocks ranges from about 0.9×10^{-6} per °C to 16×10^{-6} per °C. From the above it could be seen that while there is thermal compatibility between the aggregate and concrete or aggregate and paste at higher range, there exists thermal incompatibility between aggregate and concrete or aggregate and paste at the lower range. This thermal incompatibility between the aggre-

الطبيعية تتراوح من ٧٠٠ كجم/سم^٢ إلى ٢٠٠٠ كجم/سم^٢ وأكثر ولذلك يفيد معرفة مقاومة الركाम الكبير للتهشيم فى حالات الخرسانة الخاصة بالرصف والمعرضة للتآكل بالاحتكاك وتحدد تلك المقاومة بمعامل التهشيم طبقا للاختبار الخاص بذلك ويعتبر أيضا معامل التهشيم دلالة على مدى مقاومة الركام للصدمات (متانة الركام).

٢-٤ صلادة الركام

تعتبر صلادة الركام، وهى خاصية مقاومته للتآكل، هامة فى الخرسانة المستخدمة فى رصف الطرق. ويتعين صلادة الركام بأجراء اختبار البرى على عينه أسطوانية الشكل ويمكن بيان صلادة الركام كمجموعه وذلك باختبار لوس أنجلوس حيث تعرض مجموعه من حبيبات الركام ذات وزن معلوم وموضوعه فى أسطوانة حديدية إلى الدوران بمعدل ١٠ إلى ٣١ دورة فى الدقيقة وتعتبر عن صلادة الركام فى هذه الحالة بالنسبة المئوية للفقد فى وزن الركام نتيجة البرى.

٣-٤ متانة الركام

يمكن تعريف متانة الركام بمقاومة الركام للانهيال بتأثير أحمال الصدم. وتعين متانة الركام بأجراء اختبار المتانة على عينة أسطوانية الشكل قطرها ٢٥ مم وارتفاعها ٢٥ مم وفى هذا الاختبار تسقط مطرقة قياسية وزنها ٢ كجم من ارتفاع سنتيمتر واحد على عينة الاختبار ثم يكرر ذلك مع زيادة ارتفاع السقوط فى كل مرة عن سابقتها بمقدار سنتيمتر واحد ويكون عدد الدقات اللازمة لكسر العينة هو مقياس متانة الركام.

٥ الخواص الكيميائية للركام

١-٥ التفاعل القلوى للركام

إذا أستعمل ركام من شكل معين متبلر من السيلكا يتواجد فى بعض الصخور البركانية الحامضية مع أسمنت به نسبة عالية من القلويات فيحدث تفاعل بين هذا الركام والقلويات ينتج عنه زيادة فى الحجم تحت أحيانا بعد سنتين أو أكثر من صب الخرسانه وينتج عن هذه الزيادة تشرخ وتفتت الخرسانه ويمكن تلخيص هذه العملية فيما يلى :-

أثناء عملية الخلط والمدة التى تليها تذوب كميته كبيره من القلويات الموجودة بالأسمنت ، ومع استمرار تفاعل الأسمنت مع الماء فان السليكات والومنيات الكالسيوم الموجودة بعينة الأسمنت تمتص الماء فتجعل المحلول أكثر قلوية ثم شديدة القلوية ويهاجم هذا المحلول الشديد القلوية أجزاء الركام السهلة التأثر مكونا جيلاتينات من السليكا القلوية وهذه الجيلاتينات (الهلاميات) تتصف بالشفافية للماء ولذلك فأنها تمتص الماء بشده من المحلول مكونه ضغطا هيدروليكيًا داخليا بالخرسانة يصل أحيانا إلى حوالى ٤٠ كجم/سم^٢ وعلى ذلك فان الضغوط التى تتعدى قيمتها قوة تحمل الخرسانه فى الشد تسبب تشرخ الخرسانه بشروخ شعيرية دقيقة جدا. وتعمل زيادة تكون المدة الهلامية سائلة الذكر على

زيادة وتوسيع رقعه الشروخ الدقيقة وتصعد إلى سطح الخرسانه خلال هذه الشروخ المادة الهلامية ويتسبب ذلك فى ضعف مقاومة الخرسانه وليس هناك معلومات كاملة عن نوع الركام الذى يتسبب فى هذا التفاعل الذى يحدث إذا أستعمل هذا الركام مع الأسمنت المحتوى على نسبة عالية من القلويات. وعلى ذلك لملافاة هذا التفاعل يراعى تحديد نسبة القلويات بالأسمنت وقد حددتها بعض المواصفات بما لا يزيد عن ٠,٦ % من وزن الأسمنت ومن حسن الحظ لم تظهر بالأعمال الخرسانية فى مصر حتى الآن أى أثر لظاهرة التفاعل القلوى للركام.

٢-٥ المواد العضوية بالركام

توجد المواد العضوية بكميات متفاوتة بالركام الطبيعى سواء من الحجر أو من عمليات النقل ويفيد غسل الركام فى إزالة المواد الذائبة منها ووجودها بكميات كبيره بالركام يضر بالخرسانة حيث قد تتفاعل مع الأسمنت أو تغلف الحبيبات فتمنع التماسك أو تؤخر من شك وتصلد الأسمنت وبالتالي تضعف الخرسانه.

٣-٥ العناصر والأملاح غير المرغوبة بالركام

الفحم ومخلفاته وعناصر الكبريتور مثل كبريتور الحديد والميكا والأملاح الكيميائية الذائبة وخاصة أملاح الكلوريدات والكبريتات وجميعها تسبب ضعفا للخرسانة إذا أحتوها بعضها أو كلها الركام وذلك لتفاعلها مع الأسمنت و حديد التسليح أو نتيجة تكوين طبقات هشّة بالخرسانة كالميكا أو لزيادة حجم الخرسانة متسببا فى الشروخ.

وتنص المواصفات القياسية المصرية للركام ٩٢-١١٠٩ على أن الحد الأقصى لمحتوى أيون الكلوريد لا تزيد عن الحدود المعطاة فى الجدول التالى:

جدول رقم (٩): الحدود القصوى لأيونات الكلوريد بالركام

نوع الخرسانة	الحد الأقصى لمحتوى أيون الكلوريد كنسبة مئوية بالوزن من خليط الركام
- الخرسانة سابقة الإجهاد والخرسانة المعالجة بالبخار	٠,٠٢
- الخرسانة المصنوعة من الأسمنت عالى المقاومة للكبريتات والأسمنت المقاوم للكبريتات	٠,٠٤
- الخرسانة المسلحة المصنوعة من الأسمنت البورتلاندى العادى	٠,٠٦ (متوسط ٩٥% من النتائج بحيث لا تزيد أى نتيجة من النتائج عن ٠,٠٨)

Table 3-6

Dissolved silica and reduction in alkalinity of some Indian aggregates

Sl. No.	Description of Aggregate	Reduction in Alkalinity millimoles per litre—Ra	Dissolved Silica millimoles per litre Si	Ratio Si/Ra
1.	Banihal Trap	16	42	2.63
2.	Deccan Trap (Nagpur)	320	177	0.55
3.	Rajmahal Trap (West Bengal)	252	210	0.83
4.	Banihal Quartzite	16	57	3.56
5.	Limestone	24	Nil	Nil
6.	Limestone (Balasore)	96	Nil	Nil
7.	Limestone (Banswara)	32	Nil	Nil
8.	Ennore Sand	4	Nil	Nil
9.	Gravelly Sand No. 1 (Banihal)	68	Nil	Nil
10.	Gravelly Sand No. 2 (Banihal)	100	Nil	Nil
11.	Pyrex Glass	160	926	5.79
12.	Opal	120	721	6.01

Table 3-7

Alkali Content in Indian Cement

No. of samples	Alkali content per cent	Percentage of number of samples to the total
8	Below 0.40	30.8
7	0.40 — 0.60	26.9
5	0.60 — 0.80	19.2
6	0.80 — 1.00	23.1
Nil	Above 1.00	Nil

Availability of Moisture

Progress of chemical reactions involving alkali aggregate reaction in concrete requires the presence of water. It has been seen in the field and laboratory that lack of water greatly reduces this kind of deterioration. Therefore, it is pertinent to note that deterioration due to alkali-aggregate reaction will not occur in the interior of mass concrete. The deterioration will be more in the surface. It is suggested that reduction in deterioration due to alkali aggregate reaction can be achieved by the application of water-proofing agents to the surface of the concrete with a view to preventing additional penetration of water into the structure.

Temperature Condition

The ideal temperature for the promotion of alkali-aggregate reaction is in the range of 10 to 38°C. If the temperature condition is more than or less than the above, it may not provide an ideal situation for the alkali-aggregate reaction.

Mechanism of Deterioration of Concrete Through the Alkali-Aggregate Reaction

The mechanism of alkali aggregate reaction has not been perfectly understood. However, from the known information, the mechanism of deterioration is explained as follows:—

The mixing water turns to be a strongly caustic solution due to solubility of alkalis from the cement. This caustic liquid attacks reactive silica to form alkali-silica gel of unlimited swelling type. The reaction proceeds more rapidly for highly reactive substances. If continuous supply of water and correct temperature is available, the formation of silica gel continues unabated. This silica gels grow in size. The continuous growth of silica gels exert osmotic pressure to cause pattern cracking particularly in thinner sections of concrete like pavements. Conspicuous effect may not be seen in mass concrete sections.

The formation of pattern cracks due to the stress induced by the growth of silica gel results in subsequent loss in strength and elasticity. Alkali-aggregate reaction also accelerates other process of deterioration of concrete due to the formation of cracks. Solution of dissolved carbon dioxide, converts calcium hydroxide to calcium carbonate with consequent

NAGA HAMMADI BARRAGE JV

A joint venture between Vinci Construction Grands Projets / Bilfinger Berger AG / Orascom Construction Industries

Naga Hammadi, 18 December 2003
NH01/NHBDC/T/01040

Naga Hammadi Barrage Development Consultants
26A Asmat Fahmy Street,
Mirghany, Heliopolis, Cairo
Arab Republic of Egypt

Attn.: Chief Resident Engineer, B. R. Hein
Naga Hammadi Barrage Site Office

Distribution : NHBDC: Cairo 1 copy, Site 1 Original
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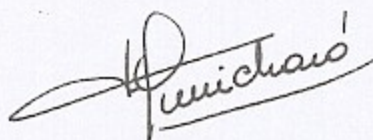
Dear Sir,

RE.: Concrete Mix Design.

Please find enclosed for your review and comments the following document:

- **NH01 P 00 JV SPE 1028 A** Concrete and Concrete Ingredients
Site Specification

Yours faithfully,



Gilles Rolland
Project Manager

GR/RE/RG

Encl.: as above detailed.

Registered office & mailing address :

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 HYDRO-POWER PLANTS EXECUTIVE AUTHORITY (HPPEA)

Naga Hammadi Barrage Development Consultants (NHBDC)

NEW NAGA HAMMADI BARRAGE AND HYDROPOWER PLANT

Lot 1 – Civil Works

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BILFINGER BERGER

VINCI
CONSTRUCTION
GRANDS PROJETS

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CONSTRUCTION INDUSTRIES

CONCRETE & CONCRETE INGREDIENTS SITE SPECIFICATION

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Reference

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1. Introduction

This document covers the requirements for the reinforced and non reinforced concrete and for the ingredients for the same as described in "Volume 3 - Particular Technical Specifications - Section 5 Concrete" from the Main Contract.

This specification for the concrete and ingredients is based on the DIN 1045:1988 and its related standards, specifications and recommendations. The requirements of the Particular Technical Specifications will be used wherever they are applicable and not contradictory to the DIN 1045. For the selection of specification with acceptance criteria and test methods the following documents and order of precedence are used:

- Main Contract - Volume 3 - Particular Technical Specifications,
- DIN standards and related documents,
- ASTM and ACI standards,
- NFP standards,
- Other standards.

The specific standards used for the specification of concrete and ingredients are listed below.

Standard	Title
Concrete	
DIN 1045:1988	Structural use of concrete
Cement	
DIN EN 197-1:2001	Cement - Composition, specifications and conformity criteria for common cements
DIN 1164-2:2000	Special Cement
DIN 1164-8:1978	Cement - Determination of heat of hydration, solution-calorimeter
DIN EN 196-1:1995	Methods of testing cement - Determination of strength
DIN EN 196-2:1995	Methods of testing cement - Chemical analysis of cement
DIN EN 196-3:1995	Methods of testing cement - Determination of setting time and soundness
DIN EN 196-6:1995	Methods of testing cement - Determination of fineness
DIN EN 196-21:1990	Methods of testing cement - Determination of the chloride, carbon dioxide and alkali content of cement
NF P 15-436:1988	Binders - Measuring the heat of hydration of cement by means of semi-adiabatic calorimetry (Langavant Method)
Fly ash	
DIN EN 450:1995	Fly ash for concrete
DIN EN 450-1:1994	Method of testing fly ash - Part 1: Determination of free calcium oxide content
DIN EN 450-2:1994	Method of testing fly ash - Part 2: Determination of fineness by wet sieving
DAfStb Code of practice: 1996	Application of fly ash according to DIN EN 450 in concrete construction
Cementitious blend	
ASTM C 596	Drying shrinkage of mortar containing hydraulic cement
Sand and aggregates	
DIN 4226-1:1983	Aggregates for concrete Aggregates of dense structure - Terminology, designation and requirements
DIN 4226-3:1983	Aggregates for concrete - Testing of heavy and lightweight aggregates
DIN 4226-1:07/2001	Aggregates for mortar and concrete - Part 1: Normal-weight and heavy

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	aggregates
DIN 52105	Testing of natural rock - Compression test
DIN EN 933-8:05/1999	Tests for geometrical properties of aggregates - Part 8: Assessment of fines - sand equivalent test
DIN EN 933-9:1998	Tests for geometrical properties of aggregates - Part 9: Assessment of fines - Methylene blue test
DIN EN 1097-2:1998	Testing for mechanical and physical properties of aggregates - Part 2 Methods for determination of resistance to fragmentation
DIN EN 1097-5:1999	Testing for mechanical and physical properties of aggregates - Part 5: Determination of water content by drying in a ventilated oven
DIN EN 1097-6:2000	Testing for mechanical and physical properties of aggregates - Part 6 Determination of particle density and water absorption
DIN EN 1367-2:1988	Tests for thermal and weathering properties of aggregates - Part 2: Magnesium sulfate test
DIN EN 1744-1:1998	Tests for chemical properties of aggregates - Part 1: Chemical analyses
NF P 18542:1994	Conventional natural aggregates for hydraulic concrete - Aggregate qualification criteria vis-à-vis the alkali reaction
ASTM C 1260 - 94	Potential alkali reactivity of aggregates (Mortar-bar method)
Mixing water	
German Concrete and Construction society: 1996	Code of practice for mixing water for concrete
Chemical admixtures	
DIN EN 480-10:1996	Admixtures for concrete, mortar and grout - test methods - Part 10: Determination of water soluble chloride content
DIN EN 480-12:1997	Admixtures for concrete, mortar and grout - test methods - Part 12: Determination of the alkali content of admixtures
ASTM C 494 M-99a	Chemical admixtures for concrete
Concrete	
DIN 1048-1:1991	Testing concrete - Testing of fresh concrete
DIN 1048-2:1991	Testing concrete - Testing of hardened concrete (specimens taken in-situ)
DIN 1048-4:1991	Test methods for concrete - Determination of the compressive strength of hardened concrete in structures and components Use of reference lines and evaluation by special methods
DIN 1048-5:1991	Testing concrete - Testing of hardened concrete (specimens prepared in mould)
DIN 1084-1:12/1978	Control (quality control) of concrete structures and reinforced concrete structures - Concrete BII on building sites
DIN 1084-3:12/1978	Control (quality control) of concrete structures and reinforced concrete structures - Ready-mixed concrete
DIN EN 12350-2:2000	Testing fresh concrete - Part 2: Slump test
ASTM C 94M - 00	Ready-mixed concrete
German Society of Concrete and Construction Technology DBV:1996	Concrete for massive structures
German Society of Concrete and Construction Technology DBV:1996	Water resistant structural members made of concrete

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2. Cement

2.1 General

The cement is produced and supplied by Egyptian Cement Company (ECC) located in the Suez area. The plant operates four dry process lines, each yielding 1.75 million tons per year, using own operated limestone and clay quarries. The plant has sufficient capacity for the cement supply of Naga Hammadi Barrage, without using any further backup facility. Other sources may however be considered during the course of the project.

The cement is delivered as bulk material by special weather-tight silo trucks and directly discharged into the storage silos at the mixing plant.

The following types of Ordinary Portland Cement of ECC according to DIN EN 197-1:2001 and DIN 1164-2:2000 are intended for use:

- CEM I 42.5 R low alkali (LA),
- CEM I 42.5 N low alkali, low heat of hydration (LA; LH).

The CEM I 42.5 N low alkali, low heat of hydration will be used as one compound for the cementitious blend of the mass concrete. For structural concrete not described as mass concrete the CEM I 42.5 R low alkali will be used.

For every delivery of cement a test certificate has to be submitted to the site, and checked for conformance, prior to discharge of the cement into the storage silos. This test certificate has to cover the chemical and physical properties of the cement. The single results of the heat of hydration and strength tests (3 days and 28 days), performed at the required ages, will be added to this test certificate and submitted to the site one working day after they are performed.

If two alternative test frequencies are used the frequency shall be applied which will be reached at first.

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2.2 Cement specification for mass concrete – Initial selection

Selected cement type CEM I 42.5 N low alkali, low heat of hydration shall comply with the following:

	Test Criteria	Acceptance criteria	Test Method
	Chemical properties		
2.2.1	Loss of ignition (LOI)	max. 5% by mass	DIN EN 196-2:05/1995
2.2.2	Insoluble residue (IR)	max. 5% by mass	DIN EN 196-2:05/1995
2.2.3	Sulphate content (SO ₃)	max. 4% by mass	DIN EN 196-2:05/1995
2.2.4	Chloride content (Cl)	max. 0.10% by mass	DIN EN 196-21:1990
2.2.5	Equivalent alkali content (Na ₂ O)	max. 0.60 % by mass	DIN EN 196-2:05/1995
2.2.6	Magnesium oxide (MgO)	max. 5% by mass	DIN EN 196-2:05/1995
2.2.7	SiO ₂ content	min. 25.0 % by mass	DIN EN 196-2:05/1995
2.2.8	Al ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995
2.2.9	Fe ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995
2.2.10	(CaO) / (SiO ₂)	min. 2.0 % by mass	DIN EN 196-2:05/1995
2.2.11	Total CaO content	Limit depending on total content in blend	DIN EN 196-2:05/1995
	Physical properties		
2.2.12	Initial setting time	min. 60 minutes	DIN EN 196-3:05/1995
2.2.13	Final setting time	Depending on data sheet	DIN EN 196-3:05/1995
2.2.14	Standard consistency (Water demand)	Depending on data sheet	DIN EN 196-3:05/1995
2.2.15	Soundness Le Chatelier stability	max. 10 mm	DIN EN 196-3:05/1995
2.2.16	Specific surface (Blaine)	Depending on data sheet	DIN EN 196-6:05/1990
2.2.17	Density	Depending on data sheet	DIN EN 196-6:05/1990
	Compressive strength		
2.2.18	2 days	min. 10 N/mm ²	DIN EN 196-1:1995
2.2.19	7 days	Depending on data sheet, no limit specified	DIN EN 196-1:1995
2.2.20	28 days	min. 42.5 N/mm ²	DIN EN 196-1:1995
2.2.21	90 days	Depending on data sheet, no limit specified	DIN EN 196-1:1995
	Miscellaneous		
2.2.22	Quality history	Period of one year	

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2.3 Cement specification for other structural concrete – Initial selection

Selected cement type CEM I 42.5 R low alkali shall comply with the following:

	Test Criteria	Acceptance criteria	Test Method
	Chemical properties		
2.3.1	Loss of ignition (LOI)	max. 5% by mass	DIN EN 196-2:05/1995
2.3.2	Insoluble residue (IR)	max. 5% by mass	DIN EN 196-2:05/1995
2.3.3	Sulphate content (SO ₃)	max. 4% by mass	DIN EN 196-2:05/1995
2.3.4	Chloride content (Cl)	max. 0.10% by mass	DIN EN 196-21:1990
2.3.5	Equivalent alkali content (Na ₂ O)	max. 0.60 % by mass	DIN EN 196-2:05/1995
2.3.6	Magnesium oxide (MgO)	max. 5% by mass	DIN EN 196-2:05/1995
2.3.7	SiO ₂ content	min. 25.0 % by mass	DIN EN 196-2:05/1995
2.3.8	Al ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995
2.3.9	Fe ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995
2.3.10	(CaO) / (SiO ₂)	min. 2.0 % by mass	DIN EN 196-2:05/1995
2.3.11	Total CaO content	Limit depending on total content in blend	DIN EN 196-2:05/1995
	Physical properties		
2.3.12	Initial setting time	min. 60 minutes	DIN EN 196-3:05/1995
2.3.13	Final setting time	Depending on data sheet	DIN EN 196-3:05/1995
2.3.14	Standard consistency (Water demand)	Depending on data sheet	DIN EN 196-3:05/1995
2.3.15	Soundness Le Chatelier stability	max. 10 mm	DIN EN 196-3:05/1995
2.3.16	Specific surface (Blaine)	Depending on data sheet	DIN EN 196-6:05/1990
2.3.17	Density	Depending on data sheet	DIN EN 196-6:05/1990
	Compressive strength		
2.3.18	2 days	min. 20 N/mm ²	DIN EN 196-1:1995
2.3.19	7 days	Depending on data sheet, no limit specified	DIN EN 196-1:1995
2.3.20	28 days	min. 42.5 N/mm ²	DIN EN 196-1:1995
2.3.21	90 days	Depending on data sheet, no limit specified	DIN EN 196-1:1995
	Miscellaneous		
2.3.22	Quality history	Period of one year	

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2.4 Cement specification for mass concrete – Routine testing

The information to be provided by the cement supplier and the site routine testing of cement type CEM I 42.5 N low alkali, low heat of hydration shall consist of the following:

	Test criteria	Acceptance criteria	Test method	Test frequency for delivery	Test frequency for routine production control
	Chemical properties				
2.4.1	Loss of ignition (LOI)	max. 5% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.2	Insoluble residue (IR)	max. 5% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.3	Sulphate content (SO ₃)	max. 4% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.4	Chloride content (Cl)	max. 0.10% by mass	DIN EN 196-21:1990	See note 1	See note 2
2.4.5	Equivalent alkali content (Na ₂ O)	max. 0.60 % by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.6	Magnesium oxide (MgO)	max. 5% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.7	SiO ₂ content	min. 25.0 % by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.8	Al ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.9	Fe ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.10	(CaO) / (SiO ₂)	min. % 2.0	DIN EN 196-2:05/1995	See note 1	See note 2
2.4.11	Total CaO content	Limit depending on total content in blend	DIN EN 196-2:05/1995	See note 1	See note 2
	Physical properties				
2.4.12	Initial setting time	min. 60 minutes	DIN EN 196-3:05/1995	See note 1	Every 1000 tons
2.4.13	Final setting time	Limit depending on data sheet	DIN EN 196-3:05/1995	See note 1	Every 1000 tons
2.4.14	Standard consistency (Water demand)	Limit depending on data sheet	DIN EN 196-3:05/1995	See note 1	Every 1000 tons
2.4.15	Soundness Le Chatelier stability	max. 10 mm limit to meet the 3mm required for the cementitious blend	DIN EN 196-3:05/1995	See note 1	Every 1000 tons
2.4.16	Specific surface (Blaine)	Limit depending on data sheet	DIN EN 196-6:05/1990	See note 1	Every 1000 tons
2.4.17	Density	Limit depending on data sheet	DIN EN 196-6:05/1990	See note 1	Every 1000 tons
	Compressive strength				
2.4.18	2 days	min. 10 N/mm ² Limit according to data sheet	DIN EN 196-1:1995	See note 1	Every 1000 tons
2.4.19	7 days	Not specified	DIN EN 196-1:1995	See note 1	Every 1000 tons

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2.4.20	28 days	min. 42.5 N/mm ² Limit according to data sheet	DIN EN 196-1:1995	See note 1	Every 1000 tons
2.4.21	90 days	Not specified Limit according to data sheet	DIN EN 196-1:1995	See note 1	Every 1000 tons
	Miscellaneous				
2.4.22	Quality history	Permanent recording		Monthly update performed by the supplier	
2.4.23	Date of production			See note 1	
2.4.24	Batch n°			See note 1	
2.4.25	Storage limitation	Max 120 days for bulk material			
2.4.26	Cement temperature at delivery	Max. 60°C		See note 1	

Note 1 : Test certificate for every shipment delivered

Note 2 : Values of test certificate; further analysis in case of doubt only

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2.5 Cement specification of cement for other structural concrete – Routine testing

The information to be provided by the cement supplier and the site routine testing of cement type CEM I 42.5 R low alkali shall consist of the following:

	Test criteria	Acceptance criteria	Test method	Test frequency for delivery	Test frequency for routine production control
	Chemical properties				
2.5.1	Loss of ignition (LOI)	max. 5% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.5.2	Insoluble residue (IR)	max. 5% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.5.3	Sulphate content (SO ₃)	max. 4% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.5.4	Chloride content (Cl)	max. 0.10% by mass	DIN EN 196-21:1990	See note 1	See note 2
2.5.5	Equivalent alkali content (Na ₂ O)	max. 0.60 % by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.5.6	Magnesium oxide (MgO)	max. 5% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.5.7	SiO ₂ content	min. 25.0 % by mass	DIN EN 196-2:05/1995	See note 1	See note 2
2.5.8	Al ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995	See note 1	See note 2
2.5.9	Fe ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995	See note 1	See note 2
2.5.10	(CaO) / (SiO ₂)	min. 2.0 % by mass	DIN EN 196-2:05/1995	See note 1	See note 2
	Physical properties				
2.5.11	Initial setting time	min. 60 minutes	DIN EN 196-3:05/1995	See note 1	Every 1000 tons
2.5.12	Final setting time	Limit depending on data sheet	DIN EN 196-3:05/1995	See note 1	Every 1000 tons
2.5.13	Standard consistency (Water demand)	Limit depending on data sheet	DIN EN 196-3:05/1995	See note 1	Every 1000 tons
2.5.14	Soundness Le Chatelier stability	max. 10 mm	DIN EN 196-3:05/1995	See note 1	Every 1000 tons
2.5.15	Specific surface (Blaine)	Limit depending on data sheet	DIN EN 196-6:05/1990	See note 1	Every 1000 tons
2.5.16	Density	Limit depending on data sheet	DIN EN 196-6:05/1990	See note 1	Every 1000 tons
	Compressive strength				
2.5.17	2 days	min. 20 N/mm ² Limit according to data sheet	DIN EN 196-1:1995	See note 1	Every 1000 tons
2.5.18	7 days	Not specified	DIN EN 196-1:1995	See note 1	Every 1000 tons
2.5.19	28 days	min. 42.5 N/mm ² Limit according to data sheet	DIN EN 196-1:1995	See note 1	Every 1000 tons
2.5.20	90 days	Not specified Limit according to data	DIN EN 196-1:1995	See note 1	Every 1000 tons

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		sheet			
	Miscellaneous				
2.5.21	Quality history	Permanent recording		Monthly update performed by the supplier	
2.5.22	Date of production			See note 1	
2.5.23	Batch n°			See note 1	
2.5.24	Storage limitation	Max 120 days for bulk material			
2.5.25	Cement temperature at delivery	Max. 60°C		See note 1	

Note 1 : Test certificate for every shipment delivered

Note 2 : Values of test certificate. Analysis in case of doubt

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3. Fly Ash

3.1 General

One source of fly ash is intended for use to cover the required quantities. Fly ash is produced at "Wanakbor Plant, India" and supplied by "GEOS".

Fly ash will be according to DIN EN 450 and the related document "German Committee for Reinforced Concrete: Application of Fly Ash according to DIN EN 450 for Concrete Structures".

The fly ash is shipped in big bags to an Egyptian harbour and delivered to site by trucks. For storage of the fly ash a special storage facility is provided to minimise negative effects out of the environment on the quality of fly ash.

To provide a continuous supply for the concrete production the fly ash is discharged into storage silos, same as for cement, by using special provision of transport facilities.

The fly ash will be randomly and visually inspected for contamination and for lumps caused by moisture on site prior to discharge into the storage silo.

Fly ash will be used as one compound for the cementitious blend of mass concrete. For structural concrete not described as mass concrete fly ash may also be employed in case required.

For every delivery of fly ash a test certificate has to be submitted to the site. This certificate shall be checked for conformance, prior to discharge of the fly ash into the storage facilities. This test certificate has to cover the chemical and physical properties. The single results of the strength tests, performed at the required ages, will be added to this test certificate and submitted to the site one working day after they are performed.

The same test frequency as used for cement will be applied for a verification of the fly ash quality during production.

When needed, the reference cement used for fly ash testing (soundness, strength activity index) should be the Portland cement used for the cementitious blend.

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3.2 Fly ash specification for mass concrete – Initial Selection

Selected fly ash DIN EN 450 shall comply with the following:

	Test Criteria	Acceptance criteria	Test Method
	Chemical properties		
3.2.1	Loss of ignition (LOI)	max. 5% by mass	DIN EN 196-2:05/1995
3.2.2	Insoluble residue (IR)	Limit depending on data sheet	DIN EN 196-2:05/1995
3.2.3	Sulphuric anhydride (SO ₃)	max. 3% by mass	DIN EN 196-2:05/1995
3.2.4	Chloride content (Cl)	max. 0.10% by mass	DIN EN 196-21:1990
3.2.5	Equivalent alkali content (Na ₂ O)	max. 4.0 % by mass (to meet the limit for calculation of the cementitious blend of 0.6%)	DIN EN 196-2:05/1995
3.2.6	SiO ₂ content	min. 25.0 % by mass	DIN EN 196-2:05/1995
3.2.7	Al ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995
3.2.8	Fe ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995
3.2.9	MgO content	Limit depending on data sheet	DIN EN 196-2:05/1995
3.2.10	Total CaO content	Limit depending on total content in blend	DIN EN 196-2:05/1995
3.2.11	CaO free	max 1% by mass	DIN EN 451-1:1994
	Physical properties		
3.2.12	Fineness retaining 45 µm sieve	max. 40%, deviation +/- 10% by mass	DIN EN 451-2:1994
3.2.13	Standard consistency (Water demand)	Depending on data sheet	DIN EN 196-3:05/1995
3.2.14	Soundness Le Chatelier stability	max. 10 mm limit to meet the requirement of the cementitious blend	DIN EN 196-3:05/1995
3.2.15	Specific surface (Blaine)	Depending on data sheet	DIN EN 196-6:05/1990
3.2.16	Particle density	Deviation max +/-150 kg/m ³ to average Depending on data sheet	DIN EN 196-6:05/1990
	Strength activity index		
3.2.17	28 days	min. 75% of control mix	DIN EN 196-1:1995
3.2.18	90 days	min. 85% of control mix	DIN EN 196-1:1995
	Miscellaneous		
3.2.19	Quality history	Period of one year	

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3.3 Fly ash specification for concrete – Routine testing

The information to be provided by the fly ash supplier and the site routine testing of fly ash DIN EN 450 shall consist of the following:

	Test criteria	Acceptance criteria	Test method	Test frequency for delivery	Test frequency for routine production control
	Chemical properties				
3.3.1	Loss of ignition (LOI)	Limit depending on data sheet	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.2	Insoluble residue (IR)	max. 5% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.3	Sulphuric anhydride (SO ₃)	max. 3% by mass	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.4	Chloride content (Cl)	max. 0.10% by mass	DIN EN 196-21:1990	See note 1	See note 2
3.3.5	Equivalent alkali content (Na ₂ O)	max. 4% by mass (to meet the limit for the calculation of the cementitious blend of 0.6%)	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.6	SiO ₂ content	min. 25.0 % by mass	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.7	Al ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.8	Fe ₂ O ₃ content	Limit depending on data sheet	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.9	MgO content	Limit depending on data sheet	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.10	Total CaO content	Limit depending on total content in blend	DIN EN 196-2:05/1995	See note 1	See note 2
3.3.11	CaO free	max 1% by mass	DIN EN 451-1:1994	See note 1	See note 2
	Physical properties				
3.3.12	Fineness retaining 45 µm sieve	max. 40%, deviation +/- 10% by mass	DIN EN 451-2:1994	See note 1	Every 1000 tons of Portland cement
3.3.13	Standard consistency (Water demand)	Limit depending on data sheet	DIN EN 196-3:05/1995	See note 1	Every 1000 tons of Portland cement
3.3.14	Soundness Le Chatelier stability	max. 10 mm limit to meet the requirement for the cementitious blend	DIN EN 196-3:05/1995	See note 1	Every 1000 tons of Portland cement
3.3.15	Specific surface (Blaine)	Limit depending on data sheet	DIN EN 196-6:05/1990	See note 1	Every 1000 tons of Portland cement
3.3.16	Particle density	Deviation max +/- 150 kg/m ³ to average. Depending on data sheet	DIN EN 196-6:05/1990	See note 1	Every 1000 tons of Portland cement

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	Strength activity index				
3.3.17	28 days	Min. 75% of control mix	DIN EN 196-1:1995	See note 1	Every 1000 tons of Portland cement
3.3.18	90 days	Min. 85% of control mix	DIN EN 196-1:1995	See note 1	Every 1000 tons of Portland cement
	Miscellaneous				
3.3.19	Quality history	Permanent recording			Monthly update performed by the supplier
3.3.20	Batch n°			See note 1	
3.3.21	Fly ash temperature at delivery	max 60 °C		See note 1	
3.3.22	Storage limitation	max 120 days for bulk material			

Note 1 : Test certificate for every shipment delivered

Note 2 : Values from test certificates; further analysis in case of doubt only

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4. Cementitious Blend

4.1 General

To control the heat of hydration caused by the total amount of Portland cement in the concrete mix a cementitious blend will be used. This blend will be applied for all structures, which are classified as mass concrete to obtain the maximum core temperature of 53°C. Cementitious blends for mass concrete structures were already successfully used at projects in Upper Egypt.

For the cementitious blend a composition of CEM I 42.5 N, low heat, low alkali, DIN EN 197, and fly ash, DIN EN 450, is intended for use. For verification of the total temperature rise inside the concrete core the suitability of the composition will be confirmed by large-scale trials.

The two constituents for the cementitious blend will be separately stored and batched in the mixer.

As the cementitious blend will be produced during batching and mixing from the Portland cement and the fly ash no separate delivery control will be applied.

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4.2 Cementitious blend specification for mass concrete – Initial selection

Selected cementitious blend shall comply with the following:

	Test Criteria	Acceptance criteria	Test Method
	Chemical properties		
4.2.1	Sulphuric anhydride (SO ₃)	max. 5% by mass	DIN EN 196-2:05/1995
4.2.2	Chloride content (Cl)	max. 0.15% by mass	DIN EN 196-21:1990
4.2.3	Equivalent alkali content (Na ₂ O) by calculation	max. 0.60 % by mass	DIN EN 196-2:05/1995
4.2.4	Total CaO content	max. 45 % by mass	DIN EN 196-2:05/1995
	Physical properties		
4.2.5	Standard consistency (Water demand)	Depending on data sheet	DIN EN 196-3:05/1995
4.2.6	Initial setting time	min. 90 minutes	DIN EN 196-3:05/1995
4.2.7	Soundness Le Chatelier stability	max. 3 mm	DIN EN 196-3:05/1995
4.2.8	Heat of hydration @ 5 days for elements in contact with water	max. 200 J/g	NF P 15-436 Langavant bottle
4.2.9	Heat of hydration @ 5 days for elements not in contact with water	max. 250 J/g	NF P 15-436 Langavant bottle
4.2.10	Drying shrinkage of mortar @ 28 days	max. 0.08%	ASTM C 596
4.2.11	Potential alkali silica reactivity	Limits according to classification of NF P 18-542	NF P 18-542
	Strength		
4.2.12	90 days	min. 25 N/mm ²	DIN EN 196-1:1995

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4.3 Cementitious blend specification for mass concrete – Routine testing

Site routine testing of the cementitious blend shall consist of the following:

	Test criteria	Acceptance criteria	Test method	Test frequency for routine production control
	Chemical properties			
4.3.1	Sulphuric anhydride (SO ₃)	max. 5% by mass	Calculations based on the results of cement and fly ash	Every 5000 tons from factory certificates values or by analysis in case of doubt
4.3.2	Chloride content (Cl)	max. 0.15% by mass	Calculations based on the results of cement and fly ash	Every 5000 tons from factory certificates values or by analysis in case of doubt
4.3.3	Equivalent alkali (Na ₂ O) content by calculation	max. 0.6% by mass	Calculations based on the results of cement and fly ash	Every 5000 tons from factory certificates values or by analysis in case of doubt
4.3.4	Total CaO content	max. 45% by mass	Calculations based on the results of cement and fly ash	Every 5000 tons from factory certificates values or by analysis in case of doubt
	Physical properties			
4.3.5	Standard consistency (Water demand)	Depending on data sheet	DIN EN 196-3:05/1995	Every 1000 tons or every month of Portland cement
4.3.6	Initial setting time	min. 90 min	DIN EN 196-3:05/1995	Every 1000 tons or every month of Portland cement
4.3.7	Soundness Le Chatelier stability	max. 3 mm	DIN EN 196-3:05/1995	Every 1000 tons or every month of Portland cement
4.3.8	Heat of hydration for Portland cement	to meet the calibration curve to meet the 53 °C criteria	NF P 15-436 Langavant bottle	Every 5000 tons or every 3 months of Portland delivery
	Strength			
4.3.9	90 days	Min. 25 N/mm ²	DIN EN 196-1:1995	Every 1000 tons or every month of Portland cement

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5. Sand and Aggregates

5.1 General

The sand and aggregates shall comply with DIN 4226:1983 and the additional properties as specified in PTS Section 5. In general the limits of the PTS will be applied if they are not in contradiction to the rules of DIN 4226. For material properties required by the PTS, which are not covered by the DIN 4226:1983 test methods, DIN EN or ASTM test methods will be used. The DIN EN test methods are very similar to identical to the methods of ASTM.

Definitions:

Natural sand and aggregates = Uncrushed and crushed dense material from natural deposits, pits or quarries.

Artificial sand and aggregates = Artificially produced crushed and uncrushed materials air-cooled blast-furnace slag or cinders.

Crushed gravel = The product resulting from the artificial crushing of gravel with substantially all fragments having at least one face resulting from fracture.

Crushed stone = The product resulting from the artificial crushing of rocks, boulders or large cobblestones, substantially all faces resulting from crushing operation.

Gravel = Coarse aggregate resulting from natural disintegration and abrasion of rock or processing of weakly bound conglomerate.

5.1.1 Alkali Silica Reactivity

Having considered the various available national standards, the NF-P method gives the most transparent classification and measures to be applied for an assessment on alkali reactivity for the classification of sources.

The alkali reactivity is tested and classified in accordance with NF P 18-542 using mineralogical and petrographic analyses combined with specified test methods. The required classification for structures like dams (prevention class C) is "not reactive (NR)" or "potential reactive with pessimum effect (PRP)". For PRP aggregates specific conditions are to be met to authorise their use.

Potential reactive aggregates may be used as well if a study of concrete formulation is carried out on an experimental basis (the alkali content can be determined above which the formula of concrete becomes expansive; such tests take about 1 year).

During production the alkali content of each ingredient will be determined for calculation of the total alkali content of the concrete mix design.

5.1.2 Sand

The sand consists of processed natural material, which is well graded and washed if necessary prior to the delivery on site. The moisture content of the sand will be

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controlled to keep it in a range, which allows the use of the required ice flake quantity for the fresh concrete temperature.

Following sources for natural sand are intended for use at present:

- Naga Mazen Labeb sand.

The source provides sufficient quantities used for the concrete production. The performance of the processing equipment is designed to meet the required amounts for concrete production.

The gradation of the sand conforms to 0 – 4a mm according to DIN 4226:1983. The gradation limits given in the PTS will not be applied as they are based on ASTM sieve sizes and in contradiction to the specified limits of materials finer than 0.075 mm for pumped concrete. The fineness modulus for DIN grading can be calculated according to the DIN 4226-1:2001. The specified ranges are different to the ASTM and PTS and have to be defined according to the sand gradation used for the concrete production, which will meet the requirements of DIN 1045 for the combined grading.

As there is only very low experience in the interpretation of the test result for equivalent sand value (DIN EN 933-8) and for blue value (DIN EN 933-9) DIN 4226:2001 recommends to specify the limits according to the regional situation, which means the limit should be based on the real grading used for production.

No test method for "total other deleterious substances" exists. In alternative deleterious substances adversely affecting the setting characteristic will be tested according to DIN 4226-3:1998 for the initial selection of sand and aggregates.

The maximum sulfate and chloride contents are according to the DIN 4226:1983 limits.

5.1.3 Aggregates

Following sources for natural aggregates are intended for use at present:

- Balabish Bahari area.

This source provides sufficient quantities used for the concrete production. The performance of the processing equipment shall be designed to meet the required amounts for concrete production.

For coarse aggregates 2 sizes of natural Wadi material will be employed for the mass concrete production. The aggregate sizes will be 4 – 16 mm and 16 – 32 mm to be in compliance with the DIN 1045 grading charts. The aggregate sizes 4 – 8 mm and 8 – 16 mm will additionally be provided in case required.

All coarse aggregate fractions will be washed on site if necessary using special equipment prior to stock piling.

5.1.4 Testing

To ensure the quality of sand and aggregates prior to delivery to the mixing plant a routine testing should also be performed at the production plant. The routine testing as specified will be performed on site.

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The soundness test will be performed once every month.

Lightweight pieces will only be tested in case of problems. An indication will already be obvious during the clay lump testing, which will be performed every day of operation.

5.2 Sand and aggregate specification for concrete – Initial selection

Selected sand and aggregates shall comply with the following:

	Test Criteria	Acceptance criteria	Test Method
	General		
5.2.1	Compressive strength of crushed rock	min. 120 MPa	DIN 52105
5.2.2	Apparent specific gravity	min. 2.6 kg/dm ³	DIN EN 1097-6:2000
5.2.3	Water absorption	max. 2 % by mass	DIN EN 1097-6:2000
5.2.4	Los Angeles coeff. > 2.5 mm	max. 40 % by mass	DIN EN 1097-2:06/1998
5.2.5	Chloride content (water soluble)	max. 0.04% by mass	DIN 4226-3:1983
5.2.6	Sulfate content (acid soluble)	max. 1 % by mass	DIN 4226-3:1983
5.2.7	Alkali silica reactivity	Classification of sand and aggregates (NR, PRP, PR) with measures to be applied for concrete	NF-P 18-542:1994
	Sand 0-4a mm		
5.2.8	Gradation	passing: 0.5 mm: max. 60% 2 mm: 55 – 85% 4 mm: min. 90% 8 mm: 100% to meet combined grading (DIN 1045)	DIN 4226-3:1983
5.2.9	Material finer than 0.063 mm	max. 2 % by mass	DIN 4226-3:1983
5.2.10	Fineness modulus	Limits according to the specified grading	DIN 4226-1:07/2001
5.2.11	Equivalent sand value	Limits according to the specified grading	DIN EN 933-8:05/1999
5.2.12	Blue value	Limits according to the specified grading	DIN EN 933-9:1998
	Deleterious substances		
5.2.13	Organic impurities (Organic matter)	no dark colour	DIN 4226-3:1983
5.2.14	Clay lumps and friable particles (Settle able solids)	max. 1% by mass	DIN 4226-3:1983
5.2.15	Lightweight particles in aggregate (coal and lignite)	max. 2% by mass	DIN EN 1744-1:1998
5.2.16	Total other deleterious substances	2 days strength min. 85% 28 days strength min. 85% of control mix	DIN 4226-3:1983
5.2.17	Soundness (magnesium sulfate test)	max. 10% by mass	DIN EN 1367-2:1988
	Coarse aggregates 4-32 mm		
5.2.18	Gradation 4-8 mm	passing: 0.25 mm: max. 3% 4 mm: max. 15% 8 mm: min. 90%	DIN 4226-1:1983

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		16 mm: 100% to meet combined grading (DIN 1045)	
5.2.19	Gradation 8-16 mm	passing: 0.25 mm: max. 3% 8 mm: max. 15% 16 mm: min. 90% 31,5 mm: 100% to meet combined grading (DIN 1045)	DIN 4226-1:1983
5.2.20	Gradation 4-16 mm	passing: 0.25 mm: max. 3% 4 mm: max. 15% 8 mm: 25 – 65% 16 mm: min. 90% 31,5 mm: 100% to meet combined grading (DIN 1045)	DIN 4226-1:1983
5.2.21	Gradation 16-32 mm	passing: 0.25 mm: max. 3% 16 mm: max. 15% 31,5 mm: min. 90% 63 mm: 100% to meet combined grading (DIN 1045)	DIN 4226-1:1983
5.2.22	Material finer than 0.063 mm	max. 0.5% by mass	DIN 4226-3:1983
5.2.23	Flat and elongated pieces	max. 25% by mass	DIN 4226-3:1983
	Deleterious substances		
5.2.24	Organic impurities (Organic matter)	no dark colour	DIN 4226-3:1983
5.2.25	Clay lumps and friable particles (Settle able solids)	max. 0.5% by mass	DIN 4226-3:1983
5.2.26	Lightweight particles in aggregate (coal and lignite)	max. 2% by mass	DIN EN 1744-1:1998
5.2.27	Total other deleterious substances	2 days strength min. 85% 28 days strength min. 85% of control mix	DIN 4226-3:1983
5.2.28	Soundness (magnesium sulfate test)	max. 15% by mass	DIN EN 1367-2:1988

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5.3 Sand and aggregate specification for concrete – Routine testing

Routine testing of sand and aggregates shall consist of the following:

	Test criteria	Acceptance criteria	Test method	Test frequency for routine production control
	General			
5.3.1	Apparent specific gravity	min. 2.6 kg/dm ³	DIN EN 1097-6:2000	Every 10 000m ³ of concrete
5.3.2	Water absorption	max. 2 % by mass	DIN EN 1097-6:2000	Every 10 000 m ³ of concrete
5.3.3	Chloride content (water soluble)	max. 0.04% by mass	DIN 4226-3:1983	Once every month
5.3.4	Sulfate content (acid soluble)	max. 1 % by mass	DIN 4226-3:1983	Once every month
5.3.5	Alkali silica reactivity	Not exceeding the specified limit according to NF P	NF-P 18-542:1994	Every 10 000 m ³ of concrete
	Sand 0 - 4a mm			
5.3.6	Gradation	passing: 0.5 mm: max. 60% 2 mm: 55 – 85% 4 mm: min. 90% 8 mm: 100% to meet combined grading (DIN 1045)	DIN 4226-3:1983	Once every operating day
5.3.7	Material finer than 0.063 mm	max. 2 % by mass	DIN 4226-3:1983	Once every operating day
5.3.8	Fineness modulus	Limits according to the specified grading	DIN 4226-1:07/2001	Once every operating day
5.3.9	Equivalent sand value	Limits according to the specified grading	DIN EN 933-8:05/1999	Once per week
5.3.10	Moisture content with working moisture meter	max. 6% by mass, variation max. 0.5% per hour	DIN EN 1097-5:1999	Once per month
5.3.11	Moisture content without working moisture meter	max. 6% by mass, variation max. 0.5% per hour	DIN EN 1097-5:1999	1 test every 8 hours of production, if condition of sand moisture changes
5.3.12	Organic impurities (Organic matter)	no dark colour	DIN 4226-3:1983	Every 2 000 m ³ of concrete
5.3.13	Clay lumps and friable particles (Settle able solids)	max. 1% by mass	DIN 4226-3:1983	Once every operating day
5.3.14	Lightweight particles in aggregate (coal and lignite)	max. 2% by mass	DIN EN 1744-1:1998	In case of problems once per day
5.3.15	Soundness (magnesium sulfate test)	max. 10% by mass	DIN EN 1367-2:1988	Once every month
	Coarse aggregates 4 - 32 mm			
5.3.16	Gradation 4-8 mm	passing: 0.25 mm: max. 3% 4 mm: max. 15% 8 mm: min. 90% 16 mm: 100%	DIN 4226-1:1983	Once every operating day

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		to meet combined grading (DIN 1045)		
5.3.17	Gradation 8-16 mm	passing: 0.25 mm: max. 3% 8 mm: max. 15% 16 mm: min. 90% 31,5 mm: 100% to meet combined grading (DIN 1045)	DIN 4226-1:1983	Once every operating day
5.3.18	Gradation 4-16 mm	passing: 0.25 mm: max. 3% 4 mm: max. 15% 8 mm: 25 – 65% 16 mm: min. 90% 31,5 mm: 100% to meet combined grading (DIN 1045)	DIN 4226-1:1983	Once every operating day
5.3.19	Gradation 16-32 mm	passing: 0.25 mm: max. 3% 16 mm: max. 15% 31,5 mm: min. 90% 63 mm: 100% to meet combined grading (DIN 1045)	DIN 4226-1:1983	Once every operating day
5.3.20	Material finer than 0.063 mm	max. 0.5% by mass	DIN 4226-3:1983	Once every operating day
5.3.21	Flat and elongated pieces	max. 25% by mass	DIN 4226-3:1983	In case of problems once per day
5.3.22	Moisture content	For calculation of mixing water	DIN EN 1097-5:1999	1 test every 8 hours of production, if condition of aggregates changes
5.3.23	Clay lumps and friable particles (Settle able solids)	max. 0.5% by mass	DIN 4226-3:1983	In case of problems once per day
5.3.24	Lightweight particles in aggregate (coal and lignite)	max. 2% by mass	DIN EN 1744-1:1998	In case of problems once per day
5.3.25	Soundness (magnesium sulfate test)	max. 15% by mass	DIN EN 1367-2:1988	Once every month

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6. Mixing Water

6.1 General

The mixing water shall comply with the German Concrete and Construction Association "Code of Practice for Mixing Water for Concrete" and additional properties of PTS Section 5. The intention of this code of practice is to determine the usability of natural water sources for concrete production and the routine testing during production on site, using prefabricated test kits.

No regular testing of the mixing water is required after the sources are established, unless required by the Employer, or when the water becomes contaminated during work.

6.2 Specification of mixing water for all concrete:

Mixing water shall comply with the following:

	Test Criteria	Acceptance criteria	Test Method
6.2.1	Colour	Colourless, light yellow	Code of practice
6.2.2	Oil and grease	Only traces	Code of practice
6.2.3	Detergent	Only minor foam, stability max. 2 minutes	Code of practice
6.2.4	Suspended solids	Max. 4 cm ³	Code of practice
6.2.5	Odour	None to slight	Code of practice
6.2.6	pH value	5.5 to 8	Code of practice
6.2.7	Chloride content	Max. 500 mg/litre	Code of practice
6.2.8	Sulfate content	Max. 2 000 mg/litre	Code of practice
6.2.9	Sugar content	Max. 100 mg/litre	Code of practice
6.2.10	Phosphate content (P ₂ O ₃)	Max. 100 mg/litre	Code of practice
6.2.11	Nitrate content (NO ₃)	Max. 500 mg/litre	Code of practice
6.2.12	Zinc content (Zn)	Max. 100 mg/litre	Code of practice
6.2.13	Organic impurities	No dark colour	Code of practice
6.2.14	Alkali- and bicarbonate	Max. 1 000 mg/litre	Code of practice
6.2.15	Total dissolved salts	Max. 500 mg/litre	Code of practice

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7. Admixtures

7.1 General

Admixtures complying with ASTM C 494 are produced and supplied by MBT Egypt or similar approved. The materials will be delivered to site ready for use in containers and stored under special provisions to protect from contamination and climate prior to their use.

The chemical and physical properties of the admixtures proposed for production will be confirmed by testing in an independent laboratory prior to use.

Every delivery will be accompanied by a technical data sheet or test report to verify that the admixtures comply with the regulations of ASTM C 494.

During concrete production no routine testing is planned. Further analysis shall take place in case of doubt only.

7.2 Admixtures specification for concrete - Initial selection

	Test Criteria	Acceptance criteria	Test Method
7.2.1	Demand for chemical admixtures	Conformance with ASTM C 494	ASTM C 494
7.2.2	Na ₂ O equivalent	max. 8.5% by mass	DIN EN 480-12:1997
7.2.3	Chloride content	limit depending on data sheet	DIN EN 480-10:1996
7.2.4	Sulfate content	limit depending on data sheet	DIN EN 480-10:1996
7.2.5	Infrared spectrum analysis	for identification of the material	ASTM C 494
7.2.6	Specific gravity	limit depending on data sheet	ASTM C 494
7.2.7	Residue by oven drying	limit depending on data sheet	ASTM C 494

7.3 Admixtures specification for concrete - Site control

	Test criteria	Acceptance criteria	Test method	Test frequency for delivery	Test frequency
7.3.1	Demand for chemical admixtures	Conformance with ASTM C 494	ASTM C 494	Product data sheet	In case of doubt only
7.3.2	Proof of identity	Conformance with delivery note	Visual inspection	Manufacturer test report or data sheet for every delivery	
7.3.3	Chloride content	limit depending on data sheet	DIN EN 480-10:1996	Manufacturer test report for every delivery	In case of doubt only
7.3.4	Sulfate content	limit depending on data sheet	DIN EN 480-10:1996	Manufacturer test report for every delivery	In case of doubt only
7.3.5	Specific gravity	limit depending on data sheet	ASTM C 494	-	Every delivery
7.3.6	Residue by oven drying	limit depending on data sheet	ASTM C 494	-	Every delivery

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8. Concrete

8.1 General

For each trial mix a detailed concrete mix design will be performed using the absolute volumetric method for calculation. The mix design will include the following details:

- Concrete mix identification number,
- Specification of the concrete mix (i.e. type of concrete, strength grade, aggregate size, consistency class),
- Content of cement, fly ash, mixing water, chemical admixtures, entrapped air, sand and each size of aggregate,
- Water / cement ratio (W/C),
- Fresh concrete density, fines content (0.125, 0.25 mm), mortar content (2 and 4 mm),
- Total contents of chloride, sulfate and Na_2O (calculated from the constituents),
- Plot of the combined grading chart according to DIN 1045 charts.

The general limits for the concrete compositions in this part are based on the requirements of DIN 1045:1988 and shall be used for the specification and definition of each concrete mix design according to the intended use and environment the concrete is exposed.

All concrete types of table 5.2 of the PTS are defined as water resistant (watertight) concretes, except the blinding concrete (DIN 1045, 6.5.7.2).

The definition of the B II quality class will be used for production, handling and quality control, except the blinding concrete.

For blinding concrete the limitation for unreinforced concrete of DIN 1045, 6.5.5.1 will be used (min. cement content 100 kg/m^3 , no limitation of water / cement ratio).

Every concrete mix has to be approved by the Employer / Consultant prior to its use for permanent structural members. An updated list of the approved mixes will be distributed to the relevant parties.

Whenever possible all trial mixes will be performed using the actual material intended for use and the mixing plant to receive material properties, which are adequate to the real concrete production. Only in some special cases the concrete may be produced in a laboratory mixer.

The routine testing for the fresh concrete properties and the production of the samples for hardened concrete properties will be performed at the place of casting.

The grading of the aggregates will be determined during the initial trials and shall conform the figures 1 to 4 of DIN 1045. The curve shall be well graded and in the limits of A/B or sector 3.

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8.2 Consistency

The consistency of DIN 1045 is determined by the flow test according to DIN 1048-1:1991. For routine control testing during production the consistency will be determined by the slump method according to DIN 12350-2:2000. The relation between slump and flow will be determined during the initial trials. For low consistencies the flow method shall be applied, as the slump is regarded as collapsed.

During the initial tests the consistency is determined in several intervals to achieve the loss of consistency versus time, the setting characteristic and the rise in fresh concrete temperature. These relations will be used to determine the period of time for the transport, discharge and placing sequence of the concrete.

The acceptance criteria for the slump will be in a range of ± 2.5 cm of the designed slump. For the flow method the slump will be in the range of ± 3 cm of the designed value.

At the beginning of every casting of concrete the consistency is adjusted at the mixing plant by performing consistency tests at the first trucks produced. The adjustment will be finished if the consistency at the mixing plant is uniform and also adjusted to the site requirements. In case of not uniform consistency during placing the adjustment has to be repeated. The maximum water content for the concrete mixes shall not be exceeded.

8.3 Strength

The compressive strength classes of DIN 1045 (6.5.1 (1)) will be determined on cubes with sizes of 200x200x200 mm. According to DIN 1045 7.4.3.5.3 also 150 mm cubes can be employed using a conversion factor of 0.95. This factor will be confirmed during the initial trials and 150 mm cubes will be used for determination of the compressive strength during routine production testing.

The compressive strength classes of DIN 1045 (table 1) does not include any B30 reference. This concrete class is here defined using linear interpolation between B25 and B35 which has to be confirmed by the Designer.

Strength class	Characteristic strength, f_{wk} , minimum compressive strength of each cube [N/mm ²]	Series strength, f_{ws} , minimum average compressive strength of each series of 3 cubes [N/mm ²]
B 25	25	30
B 30	30	35
B 35	35	40

The acceptance criteria of the strength (compressive, tensile, E-modulus) for all mass concrete, which maximum core temperature is limited to 53°C, is based on the 90 days results.

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For acceptance of the compressive strength the regulations of DIN 1045, section 6.5.1 and 7.4.3.5.2 will be used.

For the initial trials of the mass concrete 3 cubes per age of testing will be produced and tested at 7, 28, 56, 90 and 180 days to issue a plot of the strength evolution of the particular concrete mix. The 180 days values will be used to determine the factor for the strength gain later than 90 days.

During routine testing only one cube per age of testing will be sampled out of one mix truck for determination of compressive strength. For an indication of the concrete quality earlier than 90 days routine tests will be performed at 7, 28 and 90 days. The 7 and 28 day results will be compared with the results of the initial test and measures will be applied, if the strength development will be lower than expected.

The curing period of the specimens will be at least to the 7th day after casting under water and the additional time to the age of testing (21 days for 28 days test age) in air according to DIN 1048-5:1991. Cubes tested for the 7 days strength shall be stored at the air, until their surface has a dry appearance. For test ages above 28 days the cubes will be removed from the under water curing 21 days prior to testing and cured under the air conditions of DIN 1048-5:1991 (German Concrete Society for Concrete and Construction Technology "Code of Practice for Mass Concrete").

The test frequency of routine testing will be according to DIN 1045 section 7.4.3.5.1 (2). For every 500 m³ of one concrete mix design 6 samples distributed along the delivery of concrete will be taken for determination of fresh concrete properties and for production of 3 cubes for each sampling (one for each age of testing). For concrete pours less than 500 m³ one sampling has to be performed every 83 m³ of concrete for every concrete mix.

The splitting tensile strength for initial trials will be determined at 7, 28 and 90 days. For each age 3 cylinders will be tested. During routine production the age of testing for acceptance is the same as specified for the compressive strength of the particular mix. One test (1 cylinder for each test age) will be performed every 1000 m³ of a concrete mix (or every 12th compressive strength test).

The static modulus of elasticity will be determined at the same age, which is used for the acceptance criteria of the compressive strength. The DIN does not cover the testing method of the Poisson ratio. Therefore the ASTM will be applied for both tests.

As the DIN philosophy is not following the proposals of ACI and ASTM the water-cement ratios of each mix design will not be varied during the initial trials to receive a relation between w/c ratio and compressive strength.

8.4 Schmidt Hammer Testing

For the intended regular non-destructive testing of the compressive strength at structural members a reference line will be employed during initial testing for the structural concrete mixes. With this relation the compressive strength of approximately the first 20 cm of the member thickness can be determined.

This method will be employed at structural members in case of deviations of the 7, 28 and 90 days compressive strength tests. In case the non-destructive determined

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concrete strength will not meet the requirements of DIN 1045, section 6.5.1 and 7.4.3.5.2 cores will be taken out of the member in a quantity to allow an assessment of the concrete quality of the member.

8.5 Temperature control

The heat of hydration development for the mass concrete during initial testing will be determined by a large-scale trial using a 3 m x 3m x 3m concrete block with formwork and intended curing method to simulate the adiabatic conditions of the member. In addition temperature measurements will be carried out at the first in-situ structures.

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8.6 Structural and mass concrete specification – Trial mixes

Trial mixes shall comply with the following:

	Test Criteria	Acceptance criteria	Test Method
	Concrete mix design		
8.6.1	Cement content	min. 240 kg/m ³ for reinforced concrete	-
8.6.2	Water cement ratio for water resistant concrete	max. 0,70 for mass concrete thickness > 40cm max. 0,60 for all concrete thickness < 40 cm	-
8.6.3	Fines and ultra fines	Limits of table 3 DIN 1045	DIN 4226-3:1983
8.6.4	Grading limits	Well gradation in sector 3 or A/B of the grading curves of DIN 1045, figure 1 to 4	DIN 4226-3:1983
8.6.5	Total chloride content	max. 0.3% by mass of cement for 95% (single value max. 0.5%)	Calculation from constituents
8.6.6	Total sulfate content	max. 4% by mass of cement	Calculation from constituents
8.6.7	Total Na ₂ O content	max. 3.0 kg/m ³	Calculation from constituents
	Fresh concrete		
8.6.8	Consistency	As specified for the particular mix section 8.2	DIN 1048-1:1991 (DIN EN 12350-5:2000)
8.6.9	Fresh concrete density	As specified for the particular mix	DIN 1048-1:1991
8.6.10	Air content	As specified for the particular mix	DIN 1048-1:1991
8.6.11	Ambient temperature	-	-
8.6.12	Fresh concrete temperature at place of casting	max. 25°C for mass concrete max. 30°C for structural concrete	DIN 1048-1:1991
8.6.13	Heat of hydration for mass concrete	max. 53°C	Large-scale trial
	Hardened concrete		
8.6.14	Compressive strength	As specified in DIN 1045, table 1 and in section 8.3 above	DIN 1048-5:1991
8.6.15	Air dry density of hardened concrete	-	DIN 1048-5:1991
8.6.16	Splitting tensile strength	-	DIN 1048-5:1991
8.6.17	Static modulus of elasticity and Poisson's ratio	-	ASTM C 469
8.6.18	Water resistance (DIN 1045, 6.5.7.2 (1)) (watertightness)	max. 50 mm average value out of 3 tests	DIN 1048-5:1991
8.6.19	Schmidhammer testing	-	DIN 1048-4:1991
	Trial concrete production run		
8.6.20	Mixing time adjustment	At least 45 sec, by use of admixtures min. 60 sec by use of ice until ice is melted min. to obtain a homogenous mix	-
8.6.21	Performance test	Homogeneous mix	ASTM C 94

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8.7 Structural and mass concrete specification – Routine testing

Routine production control shall consist in:

	Test criteria	Acceptance criteria	Test method	Test frequency for routine production control
	Concrete mix design			
8.7.1	Concrete mix design	Approved mix design	-	Every concrete mix used for production
8.7.2	Fines and ultra fines (DIN 1045, 6.5.4)	Limits of table 3 DIN 1045	DIN 4226-3:1983	Once every day of operation (5.3 aggregates)
8.7.3	Grading limits	Well gradation in sector 3 or A/B of the grading curves of DIN 1045, fig. 1 to 4	DIN 4226-3:1983	Once every day of operation (5.3 aggregates)
8.7.4	Total chloride content	max. 0.3% by mass of cement for 95% (single value max. 0.5%)	Calculation from constituents	Every month of concrete operation
8.7.5	Total sulfate content	max. 4% by mass of cement	Calculation from constituents	Every month of concrete operation
8.7.6	Total Na ₂ O content	max. 3.0 kg/m ³	Calculation from constituents	Every month of concrete operation
	Fresh concrete			
8.7.7	Consistency	As specified for the particular mix	DIN 1048-5:1991 (DIN EN 12350-5:2000)	At the beginning of casting and at every sampling for compr. strength tests Visual inspection of every delivery
8.7.8	Fresh concrete density	As specified for the particular mix	DIN 1048-1:1991	At every sampling for compressive strength tests
8.7.9	Air content	As specified for the particular mix	DIN 1048-1:1991	At every sampling for compressive strength tests
8.7.10	Ambient temperature	-	-	At every sampling for compressive strength tests
8.7.11	Fresh concrete temperature for concrete at place of casting	max. 25°C for mass concrete max. 30°C for structural concrete	DIN 1048-1:1991	Every delivery
	Hardened concrete			
8.7.12	Compressive strength	As specified in DIN 1045, table 1 and in section 8.3 above	DIN 1048-5:1991	6 samples every 500 m ³ (each 7, 28 and 90 days) per mix and as specified in 8.1
8.7.13	Air dry density of hardened concrete	-	DIN 1048-5:1991	At every sampling for compressive strength tests
8.7.14	Splitting tensile strength	-	DIN 1048-5:1991	Every 1 000 m ³ of a concrete mix
8.7.15	In situ testing (coring)	DIN 1048-2:1991	DIN 1048-2:1991	At members in question

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8.7.16	Schmidt Hammer testing	DIN 1048-4:1991	DIN 1048-4:1991	In case of problems
	Concrete temperature			
8.7.17	Fresh concrete temperature at mixing plant	Adjusted to meet the requirement of section 8.5 above (at least 2°C less than specified for placing)	DIN 1048-1:1991	Every delivery
8.7.18	Core temperature of massive structures	Max. 53°C	-	On first massive concrete pours
8.7.19	Temperature for massive structures	Max. 20°C	-	On first massive concrete pours

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Concrete mixes

mix-design Code no.	concrete grade B	Aggregate size	Flow in cm ± 3 cm	Concrete Proportion															additive	
				water/ cementi- tious ratio	water / cement ratio acc. to DIN	type of cement	cement content kg/m³	fly-ash content kg/m³ Wnokbori india	cementitious content kg/m³	water content kg/m³	sand 0/4 mm kg/m³	4/8mm kg/m³	gravel 4/16mm kg/m³ 16/ 32mm kg/m³		manufact. type	admixture content L/m³	content kg/m³	manufact. type	content kg/m³	
(5.1) MCLBS25/2/32 Mass Concrete	25	32	51	0,38	0,47	CEM III B 32.5 N LA	275	90	365	135	754		561	567	Rheobuild 857 CA	3,3	4 1,10%			
(5.2) MCLBS25/2/32 Mass Concrete	25	32	62	0,38	0,44	CEM III B 32.5 N LA	275	90	365	135	753		561	567	Rheobuild 857 CA	4	4,85 1,33%			
(5.3) MCLBS25/2/32 Mass Concrete	25	32	57	0,38	0,44	CEM III B 32.5 N LA	275	90	365	135	753		561	567	Rheobuild 857 CA	3,4	4,1 1,12%			
(8.1) MCLBS25/2/16 Mass Concrete	25	16	51	0,39	0,48	CEM III B 32.5 N LA	285	94	379	144	868		971	0	Rheobuild 857 CA	3,5	4,2 1,10%			
(8.2) MCLBS25/2/16 Mass Concrete	25	16	62	0,39	0,48	CEM III B 32.5 N LA	285	94	379	144	867		970	0	Rheobuild 857 CA	4,2	5,1 1,35%			
(9) BLP15/3/32 Lean Concr. (pump)	15	32	48		0,60	CEM I 42,5 R LA	260		260	155	790		588	595	Rheobuild 857 CA	1,9	2,3 0,90%			
(10) BLS15/3/32 Lean Concr. (slope)	15	32			0,57	CEM I 42,5 R LA	250		250	142	807		601	608	Rheobuild 857 CA	1,6	1,9 0,75%			
(15) SST-PE35/3/32 Structural Concrete	35	32	45		0,43	CEM I 42,5 R LA	400		400	170	725		540	546	Rheobuild 857 CA	3,6	4,4 1,10%			
(16) SST-PE35/3/16 Structural Concrete	35	16	45		0,43	CEM I 42,5 R LA	410		410	174	843		943	0	Rheobuild 857 CA	3,7	4,5 1,10%			
(17) SST-PE30/3/32 Structural Concrete	30	32	45		0,45	CEM I 42,5 R LA	330		330	147	774		576	582	Rheobuild 857 CA	3	3,6 1,10%			
(18) SST-PE30/3/16 Structural Concrete	30	16	45		0,45	CEM I 42,5 R LA	340		340	151	900		1007	0	Rheobuild 857 CA	3,1	3,7 1,10%			
(29) SST-PE30/3/8 Non-Shrink Concrete	30	8	51		0,45	CEM I 42,5 R LA	380		380	169	1100	728			Rheobuild 857 CA		4,4 1,16%	Flowcable 50	2,0	
(30) SST-PE30/3/32 Structural Concrete	30	32	57		0,45	CEM I 42,5 R LA	300		300	133	798		594	601	Rheobuild 857 CA		3,5 1,17%			
(31) SST-PE30/3/16 Structural Concrete	30	16	57		0,46	CEM I 42,5 R LA	310		310	141	924		1034		Rheobuild 857 CA		1,9 0,75%			
MP25/2/04	25	4	>70		0,48	CEM III B 32,5 N LA	500		500	238	1516				Rheobuild 857 CA	4,12	5 1,00%			
MP30/3/04	30	4	>70		0,52	CEM I 42,5 R LA	500		500	258	1461				Rheobuild 857 CA	6	7,3 1,46%			

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NHBDC/NHJV/L1/01193

13 March 2004

Gilles Rolland
Project Manager
Naga Hammadi Barrage JV
7th Floor, Nasr Road
Nasr City
Cairo, Egypt

**New Naga Hammadi Barrage and Hydropower Plant
Lot 1 – Civil Works**

Subject: Mass Concrete – Gravel Pit "AL-BOSA"

References: 1) NH01-P00-JV-SPE-1028 A Concrete and Concrete Ingredients
2) Concrete Meeting held on 04 March 2004

Dear Mr. Rolland,

We refer to previous discussion on the subject mass concrete and above mentioned document (1) and meeting (2). Would you please inform us why in your investigations of gravel sources, you did not investigate the pit "AL-BOSA", some 20 km south west of the project site. This pit was suggested in the tender documents, information for tenderers, and the Contractor listed this gravel pit in his Method Statement "Concrete Production" (Annex F, IX). We advise the Contractor to follow up also this source in the investigations.

Yours Sincerely,



B. R. Hein
Chief Resident Engineer NHBDC

TE 

cc: RGBS-Site: Eng. Mohammed Abd El Aal, RE
NHBDC-Cairo: Dr. J. Kohli, PM

MEMORANDUM

Naga Hammadi, 02.03.2004

To: Mr. B. Hein (CRE NHBDC)

cc: Dr. J. Kohli (PM NHBDC)

From: Dr. R. Schmidt

Naga Hammadi Barrage Mass Concrete: Minimum Content of Cement

A. Cause

For the a/m project, huge quantities of reinforced mass concrete are required to be executed, starting from the end of this year. The Contractor has proposed to use fly ash as cement replacement. In this context the question has been raised, what is the required minimum content of cement type CEM I 42.5 (low alkali, low heat of hydration), taking into account the contractual specifications and prescribed codes.

B. DIN 1045 (July 1988)

Section 6.5.5.1 (3) states:

"Where concrete is designed for external applications, the cement content shall be equal to at least 300 kg per m³ of compacted concrete and may be reduced to 270 kg per m³ of compacted concrete when cement of strength class Z45 or Z55 is used."

Note: The proposed cement type CEM I 42.5 C corresponds to "cement of strength class Z45" as referred to in the above Clause.

For the case of using "pozzolanic additions" (as which fly ash could be considered, whereas more accurately fly ash constitutes a "cement replacement") DIN 1045.88, Section 6.3.2 (3), is applicable, wherein it states:

"... pozzolanic additions shall not be included as part of the minimum cement content and, in some cases, the w/c ratio, unless special provisions for this have been made (e.g. in a test certificate or guidelines). ..."

Thus, only in the case of existence of technically accepted and applicable "guidelines", fly ash could be accounted for as part of the minimum cement content, provided that these "guidelines" are agreed on, and that the relevant requirements contained therein are strictly adhered to.

The valid version of German code DIN EN 206-1 (July 2001), "Concrete – Part 1, Specification, performance, production and conformity" can be considered as accepted "guideline", since it is the currently valid German code for the concerned matter. In the following, the relevant regulations contained in this code are summarized.

C. DIN EN 206-1 (July 2001)

Section 4.1, with Table 1:

Exposure classes are defined under this section. According to Table 1, the applicable exposure class for the majority of mass concrete in the given project is "XC2", referring to corrosion caused by carbonisation, under predominantly wet conditions.

Annex F, with Table F.1:

For exposure class "XC2", the following limits are proposed:

Minimum content of cement: $c \geq 280 \text{ kg/m}^3$

Maximal water/cement ratio: $w/c \leq 0.60$

Section 5.2.5.2.2:

According this Section, and in case of using CEM I cement (acc. EN 197-1) in conjunction with cement replacement by fly ash, the following is applicable:

- 1.) The minimum content of cement according to Table F.1 (min $c = 280 \text{ kg/m}^3$ for the given case) may be reduced by a quantity $k \times (\text{min } c - 200 \text{ kg/m}^3)$, whereby $k = 0.4$ for CEM I 42.5, i.e. by $0.4 \times (280 \text{ kg/m}^3 - 200 \text{ kg/m}^3) = 32 \text{ kg/m}^3$ in the given case. Thus, the applicable minimum content of cement in conjunction with fly ash is 248 kg/m^3 .
- 2.) A fly ash content of up to 0.33 times the actually applied CEM I cement content may be accounted for the calculation of the applicable minimum content of cement. Thus, in the given case, the minimum content of CEM I cement in conjunction with fly ash can be calculated as $1/(1 + 0.33) \times 248 \text{ kg/m}^3 = 186 \text{ kg/m}^3$, provided that the applied fly ash content is not less than $0.33 \times 186 \text{ kg/m}^3 = 62 \text{ kg/m}^3$.
- 3.) In case of applying a fly ash content higher than 62 kg/m^3 , the quantity above this value shall not be taken into consideration for the applicable minimum content of cement.

Note: In order to satisfy the relevant strength criteria, the total content of cementitious material is envisaged to be within 330 and 360 kg/m^3 , which will have to be decided based on the results of trial mixes. Thereby, only those results will be accounted for, which have been obtained from accepted cubes prepared and crushed in presence of the Engineer.

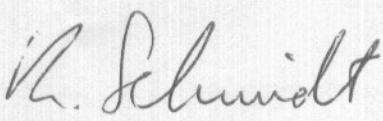
D. Calculation of the water/cement ratio in case of using fly ash:

Section 5.2.5.2.2 of DIN EN 206-1 (July 2001), here considered as "guideline" acc. to B.:

Analogously to the above, a fly ash content of only up to 0.33 times the actually applied CEM I cement content may be accounted for the calculation of the water/cement ratio (w/c), which shall made in accordance with the following formula:

$$w/c = w / [\text{CEM I content} + k \times (\text{fly ash content} \leq 0.33 \times \text{CEM I content})] \leq 0.60,$$

whereby $k = 0.4$, provided that CEM I 42.5 (acc. EN 197-1) is used.


(Dr. R. Schmidt)

ARAZEK
17/8

NAGA HAMMADI BARRAGE JV

A joint venture between Vinci Construction Grands Projets / Bilfinger Berger AG / Orascom Construction Industries

Naga Hammadi, 17 August 2004
NH01/NHBDC/T/01545

Naga Hammadi Barrage Development Consultants
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Arab Republic of Egypt

Attn.: Chief Resident Engineer, B. R. Hein
Naga Hammadi Barrage Site Office

Distribution : NHBDC: Cairo 1 copy, Site 1 Original
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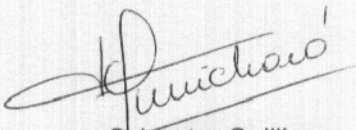
Dear Sir,

RE.: Concrete and Concrete Constituents – Expert Opinion.

Please find enclosed for your information and records the expert opinion from Mr. A. Le Roux as regards the interpretation of the ASR CEBTP measurements after 3 months.

An electronic copy of this document has been e-mailed by Mr. K Lindenbach to Dr. Schmidt.

Yours faithfully,


Sylvestre Guillien
Project Manager

FG

Encl.: as detailed above (8 A4 pages).

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Materials Consult International

Matériaux Conseil International

Quintin le 16 Août 2004

André Le Roux
16 Rue du jeu de Paume
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E-Mail : al-roux1@wanadoo.fr

V/réf. : Email du 10/03/04
Commande du 12/05/04
N/Réf. : Proposition N° 164 06 04

Objet : Naga Hammadi Barrage

VINCI Construction Grands Projets

A l'attention de **Monsieur Lionel Linger**
5 cours Ferdinand de Lesseps
92851 Rueil Malmaison Cedex

Report 4

First conclusions at half time about the
reactivity of different formulations

Dear Sir,

Please find hereafter short observations about the first results obtained at half time with different formulations and two different standards

- 1) with draft standard XP P 18-454: performance test
- 2) with standard ASTM C227-3
 - a. without suralkalinized medium
 - b. in a suralkalinized medium

It is important, for each formulation, to wait the final results but, at half time, after 3 months, not any formulation must be considered as reactive

Best regards

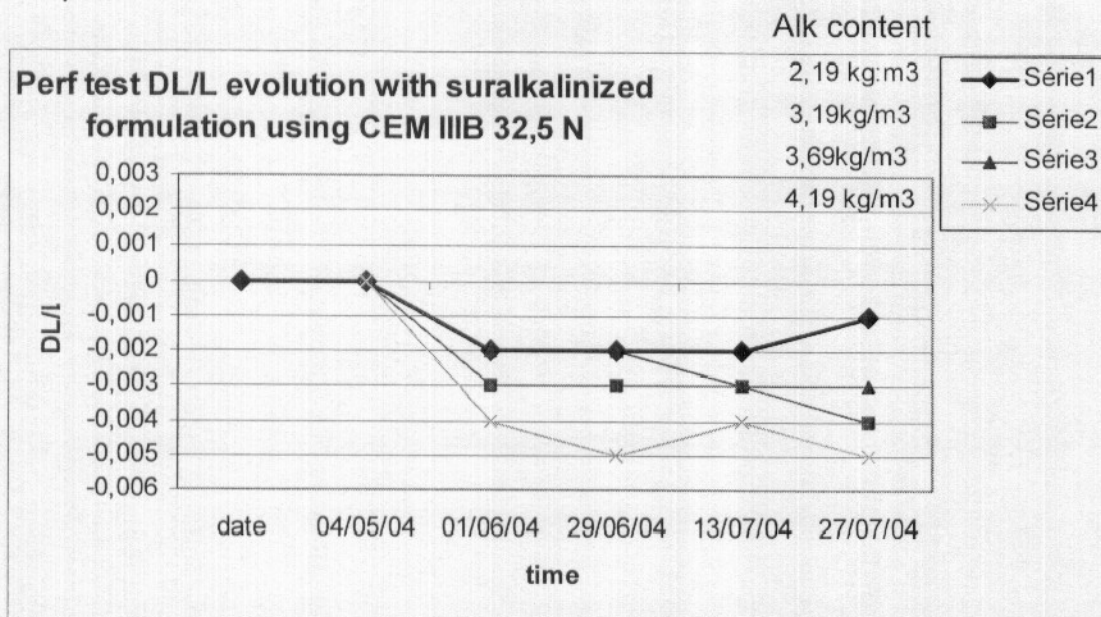
André Le Roux

Performance test (in accordance with draft standard P 18 454)

All information about each formulation is given in the CEBTP report (particularly about alkalis content, aggregates (sand and gravel) additions and rheology).

I) Test performed with formulation using CEM III B 32,5

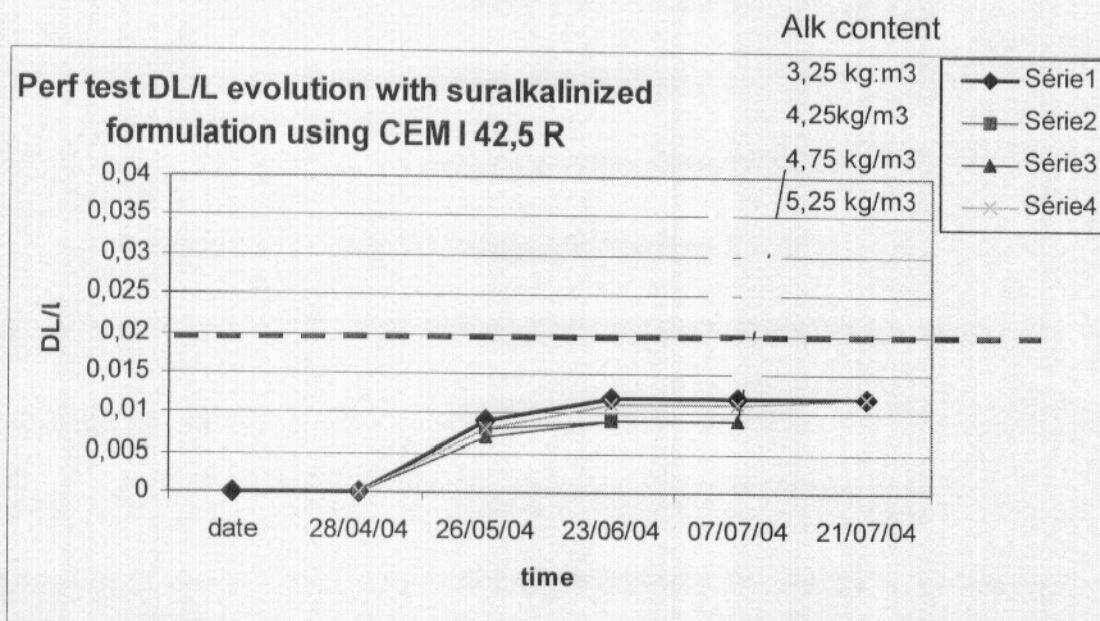
Graph of first results obtained at half time



The first results, at approximately 3 months, show that the formulation is non reactive.

II) Test performed with formulation using CEM I 42,5 R

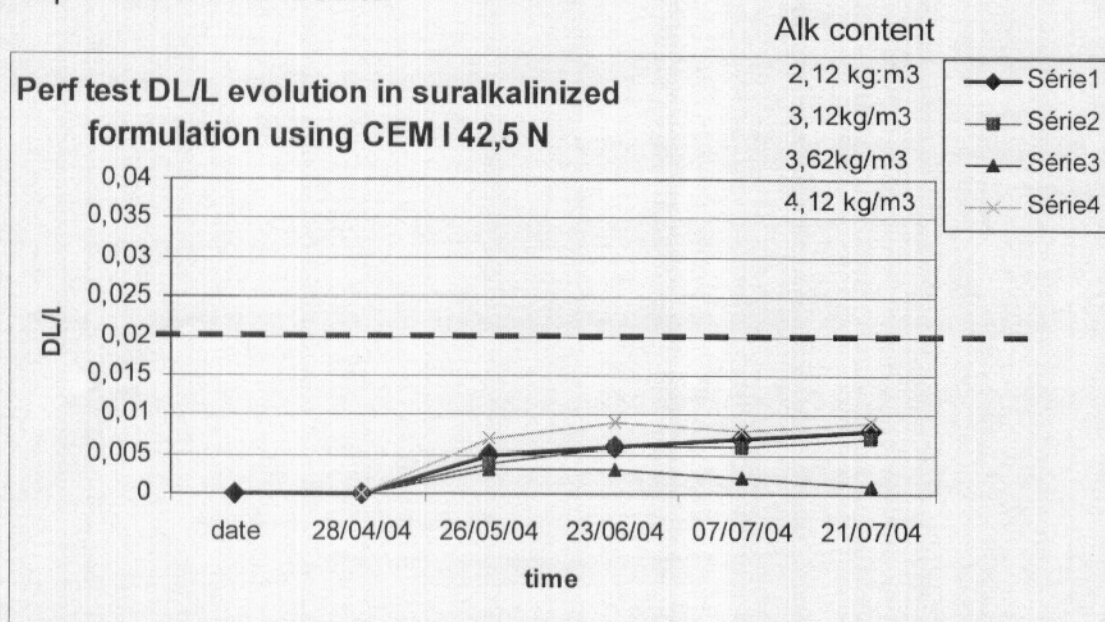
Graph of the first results



The first results, at approximately 3 months, show that the formulation is non or slightly reactive.

III) Test performed with formulation using CEM I 42,5 N

Graph of the first results



The first results, at approximately 3 months, show that the formulation is non reactive.

Tests in accordance with ASTM C 227-3

To obtain a suitable qualification with this test, it is necessary to wait for the six months results, but at the half time, all formulations are found non reactive

I) Test performed with CEMENT CEM III/B 32,5 N

POTENTIAL ALKALI REACTIVITY OF CEMENT - AGGREGATE COMBINATIONS

Tested materials

- CEM III/B 32,5 N cement - HSC
- Sand 0/4 Naga Mazen
- Fly ash Wanakbori
- Gravel 4/16 Balabish Mohee
(crushed to size < 5 mm)

NS292 - 100 % cement / sand

NO SWELLING → non reactive formulation

NS295 - 80 % cement + 20 % fly ash / sand

NO SWELLING → non reactive formulation

NS294 - 75 % cement + 25 % fly ash / sand

NO SWELLING → non reactive formulation

NS293 - 70 % cement + 30 % fly ash / sand

NO SWELLING → non reactive formulation

NS288 - 100 % cement / gravel

NO SWELLING → non reactive formulation

NS291 - 80 % cement + 20 % fly ash / gravel

NO SWELLING → non reactive formulation

NS290 - 75 % cement + 25 % fly ash / gravel

NO SWELLING → non reactive formulation

**NS289 - 70 % cement + 30 % fly ash /
gravel**

NO SWELLING → non reactive formulation

II) Test performed with CEMENT CEM I 42,5 R

POTENTIAL ALKALI REACTIVITY OF CEMENT - AGGREGATE COMBINATIONS

Tested materials

- CEM I 42,5 R cement - CE045
- Sand 0/4 Naga Mazen - Gravel 4/16 Balabish Mohee
(crushed to size < 5mm)

NS283 - 100 % cement / sand

NO SIGNIFICANT SWELLING → non or weakly reactive formulation

NS284 - 100 % cement / gravel

NO SIGNIFICANT SWELLING → non or weakly reactive formulation

III) Test performed with CEM I 42,5 N LA LH CEMENT

POTENTIAL ALKALI REACTIVITY OF CEMENT - AGGREGATE COMBINATIONS

Tested materials

- CEM I 42,5 N LA LH cement - C2ECC
- Fly ash Wanakbori
- Sand 0/4 Naga Mazen
- Gravel 4/16 Balabish Mohee
(crushed to size < 5 mm)

NS263 - 100 % cement / sand

NO SIGNIFICANT SWELLING → non or weakly reactive formulation

NS264 - 60 % cement + 40 % fly ash / sand

NO SIGNIFICANT SWELLING → non or weakly reactive formulation

NS265 - 50 % cement + 50 % fly ash / sand

NO SIGNIFICANT SWELLING → non or weakly reactive formulation

NS266 - 100 % cement / gravel

NO SIGNIFICANT SWELLING → non or weakly reactive formulation

**NS267 - 60 % cement + 40 % fly ash /
gravel**

NO SIGNIFICANT SWELLING → non or weakly reactive formulation

**NS268 - 50 % cement + 50 % fly ash /
gravel**

NO SIGNIFICANT SWELLING → non or weakly reactive formulation

.....

.....

Potential alkali reactivity of cement & aggregate combinations in accordance with ASTM C227 and specified additional alkali

I) CEM III/B 32,5 N CEMENT

Tested materials

- CEM III/B 32,5 N cement - HSC
- Gravel 4/16 Balabish Mohee (crushed to size < 5 mm)

NS318 - 100 % cement / gravel / additional alkali in order to reach around 0,65 %

NO SIGNIFICANT SWELLING

NS319 - 100 % cement / gravel / additional alkali in order to reach around 0,90 %

NO SIGNIFICANT SWELLING

II) CEM I 42,5 R CEMENT

Tested materials

- CEM I 42,5 R cement - CE045
- Gravel 4/16 Balabish Mohee (crushed to size < 5 mm)

NS320 - 100 % cement / gravel / additional alkali in order to reach around 0,65 %

NO SIGNIFICANT SWELLING

NS321 - 100 % cement / gravel / additional alkali in order to reach around 0,90 %

NO SIGNIFICANT SWELLING

III) CEM I 42,5 N LA LH CEMENT

Tested materials

- CEM I 42,5 N LA LH cement - C2ECC
- Gravel 4/16 Balabish Mohee (crushed to size < 5 mm)

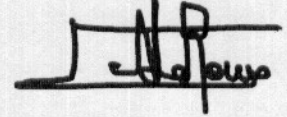
NS302 - 100 % cement / gravel / additional alkali in order to reach around 0,65 %

NO SIGNIFICANT SWELLING

NS303 - 100 % cement / gravel / additional alkali in order to reach around 0,90 %

NO SIGNIFICANT SWELLING

André Le Roux

A handwritten signature in black ink, appearing to read 'A. Le Roux', with a horizontal line drawn through the middle of the signature.